SOIL SURVEY OF

Union County, South Dakota

United States Department of Agriculture
Soil Conservation Service
In cooperation with
South Dakota Agricultural Experiment Station

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1971 to 1974. Soil names and descriptions were approved in 1974. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1974. This survey was made cooperatively by the Soil Conservation Service and the South Dakota Agricultural Experiment Station. It is part of the technical assistance furnished to the Union County Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, woodlands, and wildlife habitat; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All of the soils of Union County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the pasture group and windbreak group in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil description and from the discussions of the capability units, the pasture groups, and the windbreak groups.

Foresters and others can refer to the section "Woodland and Windbreaks" where the soils of the county are grouped according to their suitability for trees.

Wildlife managers and others can find information about soils and wildlife in the section "Wildlife."

Community planners and others can read about soil properties that affect the choice of sites for nonindustrial buildings and for recreation areas in the section "Land Use Planning."

Engineers and builders can find, under "Engineering," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about the soils in the section "Formation and Classification of the Soils."

Newcomers in Union County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "Environmental Factors Affecting Soil Use."

Cover: **Typical scene on Moody-Nora-Alcester association.**

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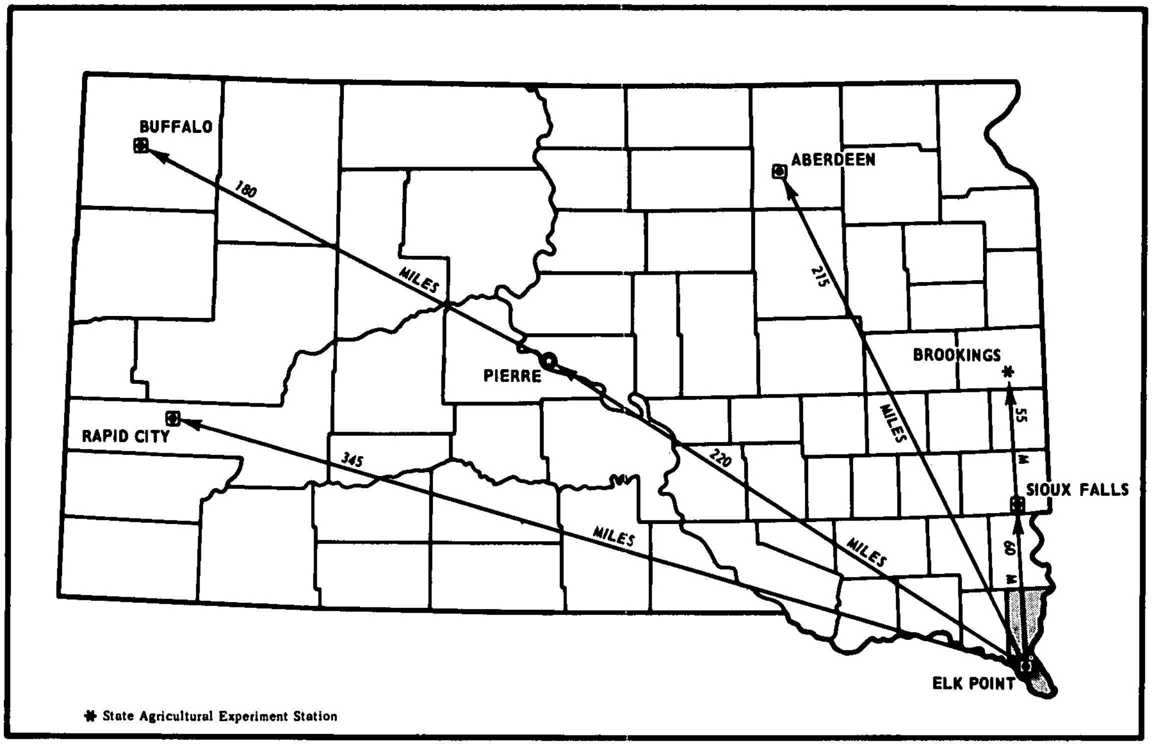

Location of Union County in South Dakota.

SOIL SURVEY OF UNION COUNTY, SOUTH DAKOTA

By James L. Driessen

Fieldwork by James L. Driessen and Regis Vialle, Soil Conservation Service

United States Department of Agriculture, Soil Conservation Service, in cooperation with the South Dakota Agricultural Experiment Station

UNION COUNTY is in the extreme southeastern corner of South Dakota in the fork of the Big Sioux and Missouri Rivers (see facing page). It has a land area of 289,216 acres and a total area of 298,240 acres. Beresford is the largest town, and Elk Point is the county seat. Other towns are Alcester, Jefferson, and North Sioux City. North Sioux City is an extension of Sioux City, Iowa.

Elevation ranges from less than 1,100 feet along the two rivers in the southeastern tip of the county to about 1,500 feet in the northwest. About half the acreage of the county is bottom land of the Big Sioux and Missouri Rivers. Relief in this part of the county is level to nearly level. Relief is rolling in much of the northern part of the county, nearly level to gently undulating on the uplands in the west, and hilly to steep in areas adjacent to the valleys of the Big Sioux River and its tributaries.

General livestock farming is the main enterprise and the main source of income. About 93 percent of the acreage is in farms, and about 82 percent of it is cropped. Corn, soybeans, oats, and alfalfa are the main crops. Barley, sorghum, and wheat are also grown. Beef cattle and swine are the main types of livestock.

Controlling erosion is a major concern in the management of cropland on uplands. Providing adequate drainage is a major concern on bottom lands. Maintaining fertility and tilth is a concern on all soils used for crops. Interest in irrigating some of the better drained soils on bottom lands is increasing. The southeastern tip of the county is subject to urbanization as the urban area around Sioux City, Iowa, expands.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Union County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes; the size and speed of streams; the kinds of native plants or crops; the kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Alcester and Worthing, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Moody silty clay loam, 0 to 2 percent slopes, is one of several phases within the Moody series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Union County: soil complexes and undifferentiated groups.

A soil complex consists of areas of two or more soils so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all

areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Egan-Shindler complex, 2 to 6 percent slopes, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. If there are two or more dominant series represented in the group, the name of the group ordinarily consists of the names of the dominant soils, joined by "and." Enet and Dempster soils, 2 to 6 percent slopes, is an undifferentiated group in Union County.

In Union County there is alluvial material so variable that it has not been classified by soil series. Such material is shown on the soil map and is described in the survey, but it is given a classification name. Fluvaquents is an example of this kind of mapping unit.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in the survey area. A soil association is a landscape that has a distinctive pattern of soils in defined proportions. It typically consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association can occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a survey area, who want to compare different parts of that area, or who want to find suitable sites for a certain kind of land use. Such a map is a useful general guide for broad planning on a watershed, a wooded tract, or a wildlife area, or for broad planning of recreation facilities, community developments, and engineering works. It is not a suitable map for detailed planning for management of a farm or field or for selecting a site for a road, building, or other structure, because the soils within an association ordinarily vary in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The boundaries of the soil associations in Union County match those of the previously published survey of Lincoln County, but there are some differences in the names because of differences in the extent of soils observed in mapping and classification. These differences do not significantly alter interpretations.

The soil associations in this survey area have been grouped into general kinds of landscapes for broad interpretative purposes. Each of the broad groups and the soil associations in it are described on the following pages.

Soils That Formed Mostly in Glacial Drift and Glacial Till; on Uplands

The two soil associations in this group consist mainly of deep, well drained and moderately well drained, silty and loamy soils that formed in glacial drift and glacial till, but there are somewhat poorly drained and poorly drained soils in the swales and numerous closed depressions scattered throughout the area. The soils are mostly nearly level to undulating but are steeper on the sides of drainageways and in the breaks adjacent to the valleys of the Missouri River and Brule Creek.

These associations make up about 14 percent of the county. The soils are used mostly for crops, but the hilly to steep soils and some of the wetter soils are used for pasture or hay. The nearly level, well drained soils have few limitations for crops. Improving drainage and maintaining tilth are management concerns on the poorly drained soils, and controlling erosion and soil blowing is a management concern on other soils.

1. Wentworth-Shindler-Worthing association

Deep, well drained and poorly drained, level to steep, silty and loamy soils

This soil association is on uplands. The areas consist of rises or swells interspersed with many closed depressions. Slopes are mostly nearly level to gently sloping, but the depressions are level, and some of the highest places are undulating. Sides of the Missouri River bottoms and the breaks of Brule Creek are rolling to hilly and steep.

This association makes up about 9 percent of the county. It is about 50 percent Wentworth soils, 25 percent Shindler soils, 15 percent Worthing soils, and 10 percent minor soils.

Wentworth soils are well drained and formed in glacial drift. They are nearly level to gently sloping and have long, smooth slopes. The surface layer is dark grayish brown silty clay loam. The subsoil is grayish brown and brown silty clay loam. The underlying material to a depth of 50 inches is light olive brown, calcareous silty clay loam. Below 50 inches it is calcareous, stratified loam and silt loam.

Shindler soils are well drained and formed in glacial till. They are gently undulating to steep on the higher parts of the landscape where the slopes are convex. The surface layer is dark gray clay loam. The subsoil is calcareous, dark gray and grayish brown clay loam. The underlying material is calcareous, light yellowish brown clay loam.

Worthing soils are poorly drained and are in flat-bottomed depressions. The surface layer is dark gray silty clay loam. The subsoil is dark gray and gray silty clay. The underlying material is calcareous, light olive gray and olive yellow silty clay loam.

The minor soils in this association are Calco and Kennebec

soils on narrow bottom lands, Chancellor soils in swales, Egan soils intermingled with Wentworth soils on rises, and Wakonda soils on the rim of depressions and on the edge of swales.

The major soils have medium to high fertility and high available water capacity. Permeability is moderate in Wentworth soils and slow in Worthing soils. Shindler soils have moderate permeability in the subsoil and moderately slow permeability in the underlying material. Runoff is slow to medium on Shindler and Wentworth soils, and it ponds on Worthing soils. Controlling erosion and maintaining fertility are the main concerns of management. Controlling wetness and maintaining tilth on Worthing soils are also concerns.

Almost all of this association is cultivated. Corn, oats, soybeans, and alfalfa are the main crops. Pastures are small and commonly near farmsteads. The potential for cultivated crops and pasture and hay plants is high.

2. Wakonda-Worthing-Chancellor association

Deep, moderately well drained to poorly drained, nearly level and level, silty soils

This soil association is on a broad upland plain. The areas consist of very slight rises that are 1 to 3 feet above many closed depressions and shallow swales. Slopes are mostly nearly level, but the flat-bottomed depressions are level. The drainage pattern is poorly defined, although the heads of a few drainageways are on the edges of the mapped area.

This association makes up about 5 percent of the county. It is about 35 percent Wakonda soils, 25 percent Worthing soils, 25 percent Chancellor soils (fig. 1), and 15 percent minor soils.

Wakonda soils are moderately well drained and are on very slight rises. The surface layer is calcareous, grayish brown silt loam. The underlying material is calcareous, light yellowish brown silt loam. Spots and streaks of gypsum salts are in the underlying material below a depth of 31 inches.

Worthing soils are poorly drained and are in depressions. The surface layer is dark gray silty clay loam. The subsoil is dark gray and gray silty clay. The underlying material is calcareous, light olive gray and olive yellow silty clay loam.

Chancellor soils are somewhat poorly drained and are in swales and on the rims of depressions. The surface layer is dark gray silty clay loam. The subsoil is dark gray and grayish brown silty clay in the upper part and light olive gray silty clay loam in the lower part. The underlying material is calcareous, light yellowish brown and gray silty clay loam.

The minor soils in this association are nearly level to gently sloping, well drained Egan and Wentworth soils on rises.

Runoff is slow in much of this association and ponds on the Worthing soils. Permeability is moderate in Wakonda soils and slow in Chancellor and Worthing soils. Wetness commonly delays farming and limits crop growth during wet years. The growth of deep-rooted crops is affected by salts in the underlying material of Wakonda soils. Wakonda soils are calcareous and are subject to soil blowing. Controlling soil blowing, maintaining tilth, and improving drainage are the main concerns of management.

Most of this association is cultivated. It is best suited to late-planted crops during wet years. In undrained areas Worthing soils are better suited to pasture and hay.

Soils That Formed Mostly in Loess; on Uplands

The two soil associations in this group consist mainly of deep, well drained, silty soils that formed in loess, but there are moderately well drained soils that formed in local alluvium on foot slopes, on fans, and on narrow bottom lands along small streams and drainageways. Slopes are long and smooth. The soils are mostly gently sloping to strongly sloping, but some are nearly level; others are strongly sloping to very steep along drainageways and on the valley sides of the Big Sioux River.

These associations make up 38 percent of the county. The soils are used mostly for crops, but the steeper soils are used for pasture and hay. Some areas are moderately to severely eroded. Controlling erosion is a major management concern.

3. Moody-Nora-Alcester association

Deep, well drained and moderately well drained, nearly level to sloping, silty soils

This soil association is on an upland plain that is mantled by silty loess. Slopes are long and smooth and are mostly gently sloping, but some are nearly level or sloping. The drainage pattern is well defined.

This association makes up about 12 percent of the county. It is about 50 percent Moody soils, 15 percent Nora soils, 15 percent Alcester soils, and 20 percent minor soils.

Moody soils are nearly level to sloping and are well drained. They have slightly concave to slightly convex slopes. The surface layer and the upper part of the subsoil are dark grayish brown silty clay loam. The middle of the subsoil is brown and pale brown silty clay loam, and the lower part is pale brown silt loam. The underlying material is calcareous, light yellowish brown silt loam.

Nora soils are mostly sloping and are well drained. They have long, smooth, mostly convex slopes. The surface layer is dark grayish brown silty clay loam. The upper part of the subsoil is brown silt loam. The lower part of the subsoil and the underlying material are calcareous, light yellowish brown silt loam.

Alcester soils are gently sloping and moderately well drained. They are on foot slopes and in narrow drainageways. The surface layer is dark grayish brown silt loam. The subsoil is dark grayish brown and grayish brown silt loam. The underlying material is light brownish gray silty clay loam.

The minor soils in this association are Calco, Kennebec, and McPaul soils on narrow bottoms along creeks and drainageways and Crofton soils on the tops and upper sides of ridges and knolls.

The major soils have medium to high fertility and high available water capacity. Permeability is moderate, and runoff is medium in most areas. Controlling erosion is the main concern of management.

Nearly all of this association is cultivated. The major soils are well suited to all crops grown in the county. Pastures are small and commonly are close to farmsteads. The potential for cultivated crops and pasture and hay plants is high.

4. Crofton-Nora-Alcester association

Deep, well drained and moderately well drained, gently sloping to very steep, silty soils

This soil association is on uplands that are mantled by loess. Slopes are long, smooth, and convex. They are mostly

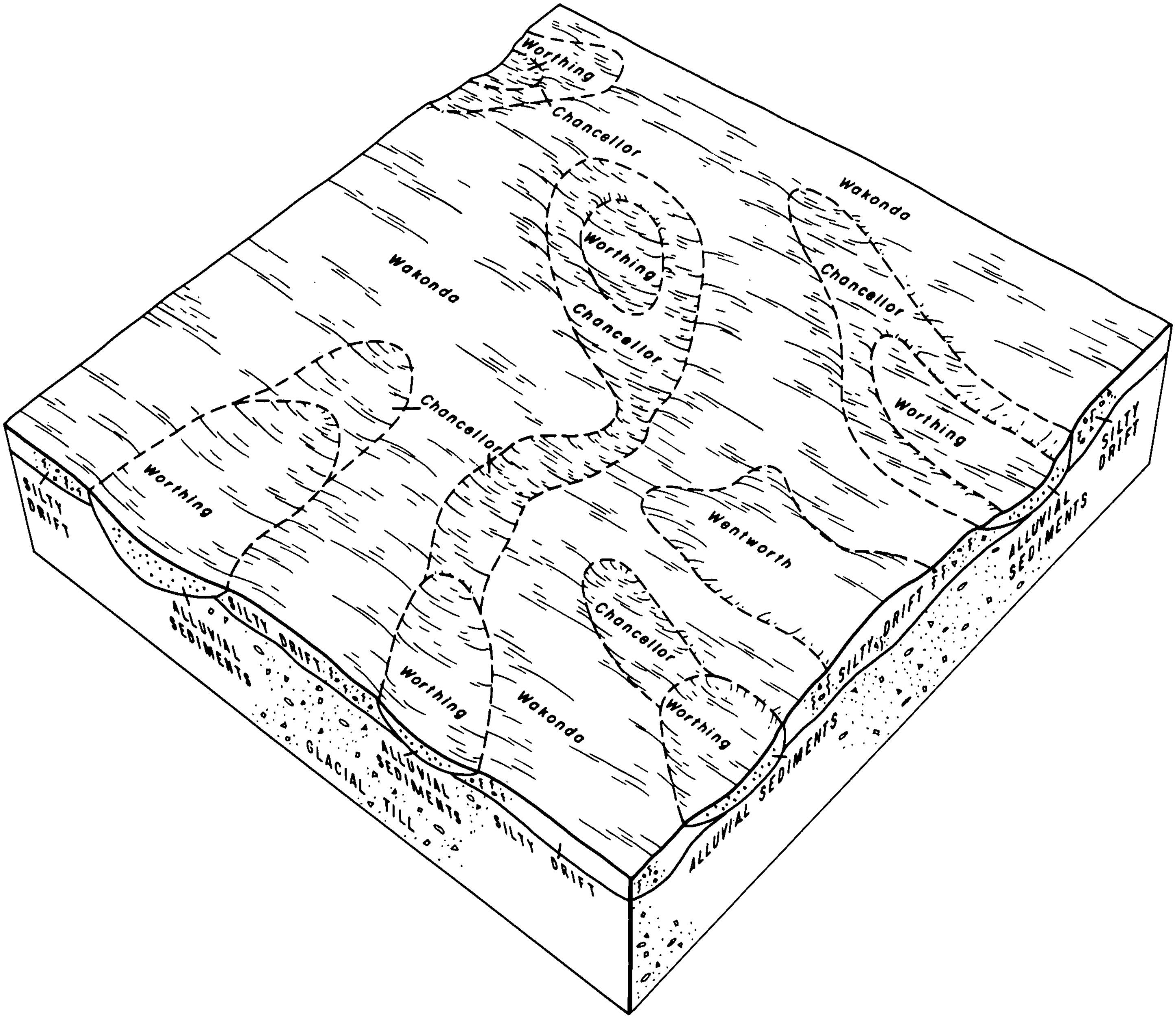

***Figure 1.*—Typical pattern of soils and underlying material in Wakonda-Worthing-Chancellor association.**

sloping to strongly sloping but are steeper on valley sides along the Big Sioux River and its larger tributaries. The drainage pattern is well defined.

This association makes up about 26 percent of the county. It is about 45 percent Crofton soils, 20 percent Nora soils, 20 percent Alcester soils (fig. 2), and 15 percent minor soils.

Crofton soils are well drained. The surface layer is calcareous, pale brown silt loam. The underlying material is calcareous, light yellowish brown silt loam.

Nora soils are well drained. The surface layer is dark grayish brown silty clay loam. The upper part of the subsoil is brown silt loam. The lower part of the subsoil and the underlying material are calcareous, light yellowish brown silt loam.

Alcester soils are gently sloping and moderately well drained. They are on foot slopes and in narrow drainageways. The surface layer is dark grayish brown silt loam. The subsoil is dark grayish brown and grayish brown silt loam. The underlying material is light brownish gray silty clay loam.

The minor soils in this association are Calco, Kennebec, and McPaul soils on narrow bottoms along creeks and drainageways, Moody soils on the lower part of concave side slopes, and Shindler soils on the lower positions on sides of entrenched drainageways where there is no mantle of loess over glacial till.

Crofton soils have low organic-matter content and low fertility. Fertility is medium in Nora soils and high in Alcester soils. Permeability is moderate throughout the association, and the available water capacity is high. Runoff

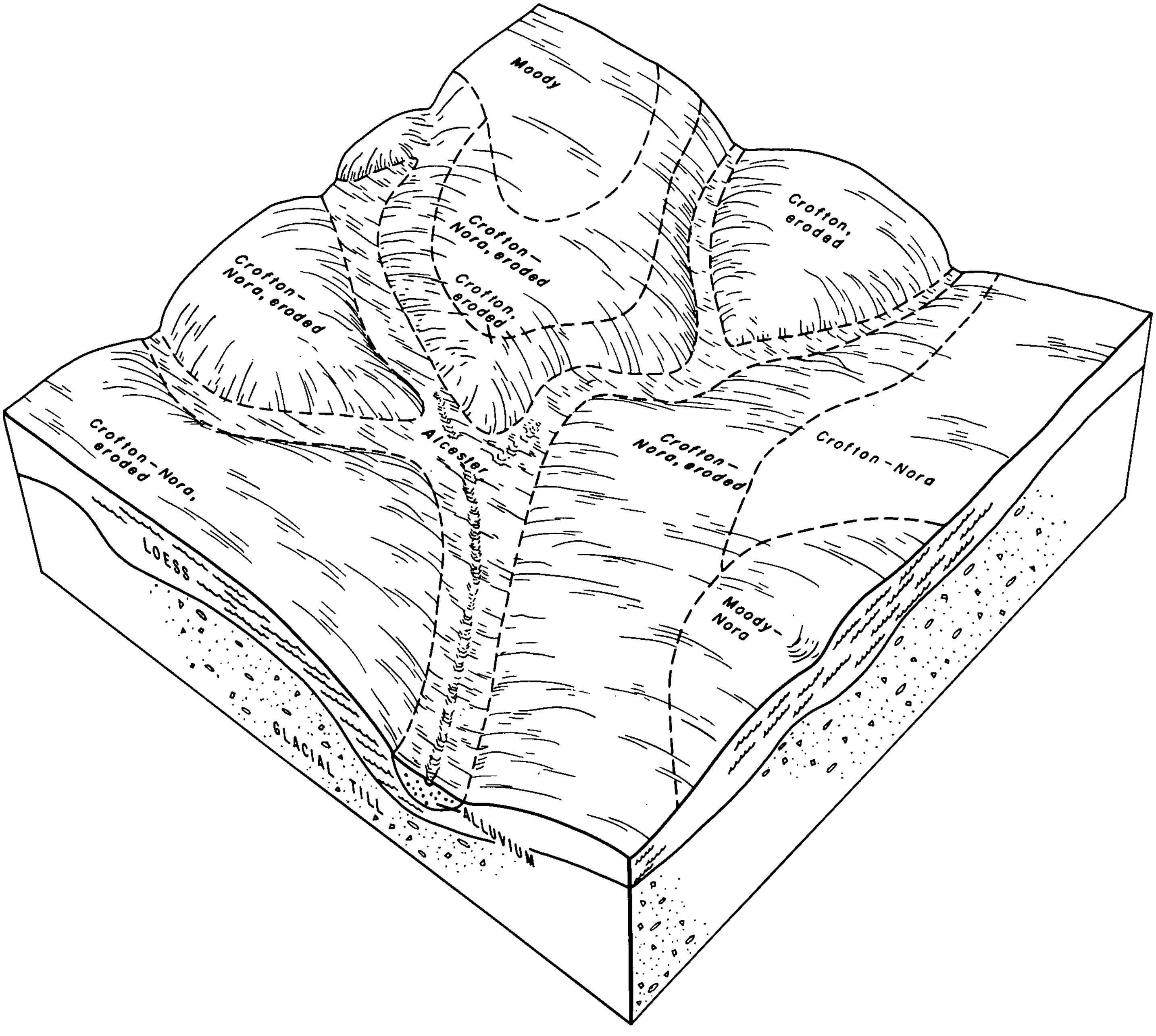

Figure 2.—**Typical pattern of soils and underlying material in Crofton-Nora-Alcester association.**

is medium to rapid, and some cultivated areas are moderately to severely eroded. Controlling erosion and improving fertility are the main concerns of management.

Much of this association is cultivated. The gently sloping and sloping soils are well suited to all crops grown in the county, but the strongly sloping to very steep soils are better suited to pasture and hay. Most of the steep and very steep soils remain in native vegetation and are used for pasture, woodland, wildlife habitat, and recreation.

Soils That Formed in Alluvium Overlying Gravelly Sand; on Stream Terraces

The only soil association in this group is on stream terraces. It consists of moderately well drained and well drained, silty

soils that are underlain by gravelly sand. The soils are mostly nearly level, but some are gently sloping.

This association makes up about 2 percent of the county. Nearly all areas are used for cultivated crops, but the soils are somewhat droughty because of the underlying gravelly sand. Conserving moisture is the main concern of management.

5. *Graceville-Dempster association*

Moderately well drained and well drained, nearly level to gently sloping, silty soils that are deep and moderately deep over gravelly sand

This soil association is on moderately high to high terraces along the Big Sioux River. Slopes are slightly concave to slightly convex and are mostly nearly level, but some are gently sloping along small drainageways and on terrace fronts.

This association makes up about 2 percent of the county. It is about 45 percent Graceville soils, 35 percent Dempster soils, and 20 percent minor soils.

Graceville soils are deep, moderately well drained, and nearly level. They have slightly concave slopes. The surface layer is dark grayish brown and dark gray silty clay loam. The subsoil is silty clay loam that is dark grayish brown in the upper part, grayish brown in the middle, and light yellowish brown in the lower part. The underlying material at a depth of 52 inches is brown gravelly sand.

Dempster soils are well drained, nearly level to gently sloping, and moderately deep over gravelly sand. The surface layer is dark grayish brown silty clay loam. The subsoil is dark grayish brown and brown silty clay loam in the upper part and yellowish brown silt loam in the lower part. The underlying material at a depth of 34 inches is yellowish brown and light yellowish brown gravelly sand.

The minor soils in this association are Benclare soils in swales and low spots, Enet soils on slight rises, Kennebec soils on fans below adjacent uplands, and Storla soils on the edges of swales and low spots.

Graceville soils have high fertility and have few limitations for crops. Dempster soils are somewhat droughty. Conserving moisture is the main concern of management. Controlling erosion is also a concern where soils are gently sloping.

Nearly all areas of this association are cultivated. Corn, oats, soybeans, and alfalfa are the main crops. These soils have good potential for irrigation, and in most places adequate water can be obtained from shallow wells. The underlying gravelly sand is a source of construction material.

Soils That Formed in Alluvium; on Bottom Lands

The six soil associations in this group consist of deep, excessively drained to very poorly drained, sandy to clayey soils that formed in alluvium. These soils are mostly level or nearly level, but some sandy soils are gently undulating to undulating.

These associations make up about 46 percent of the county. The soils are used mostly for corn, soybeans, and alfalfa, but some more poorly drained areas and wooded areas along the rivers are used for pasture, recreation, and wildlife habitat. Controlling flooding and overcoming wetness from a seasonal water table are the main concerns of management. Controlling soil blowing on sandy soils is also a concern.

6. *Sarpy-Grable-Haynie association*

Deep, excessively drained to moderately well drained, level to undulating sandy and silty soils

This soil association consists of low-lying bottom lands along the Missouri River. Slopes are mostly nearly level to gently undulating, but some are level and some are undulating. The landscape commonly is broken by former stream channels or meander scars.

This association makes up about 4 percent of the county. It is about 50 percent Sarpy soils, 25 percent Grable soils, 15 percent Haynie soils, and 10 percent minor soils.

Sarpy soils are level to undulating and are excessively drained. The surface layer is calcareous, grayish brown loamy fine sand. The underlying material is calcareous, pale brown and light gray loamy fine sand and fine sand.

Grable soils are nearly level and somewhat excessively drained. The surface layer is calcareous, grayish brown silt loam. The underlying material is calcareous, light gray silt loam and calcareous, light brownish gray very fine sandy loam to a depth of 27 inches. Below this it is calcareous, light olive brown fine sand.

Haynie soils are level and nearly level and are moderately well drained to well drained. The surface layer is calcareous, light brownish gray silt loam. The underlying material is calcareous, light brownish gray silt loam and very fine sandy loam.

The minor soils in this association are Albaton, Onawa, and Percival soils in former stream channels and meander scars. Fluvaquents also are in some of these low areas.

The major soils have moderately low organic-matter content. Sarpy soils have low fertility and blow easily. Grable and Haynie soils have medium fertility. Sarpy and Grable soils are droughty, although a seasonal water table occurs in places. Conserving moisture, controlling soil blowing, and improving fertility are the main concerns of management.

Much of this association is cultivated, but some large areas remain in native vegetation and are used for pasture, recreation, or wildlife habitat. Haynie soils have only slight limitations for crops. Unless irrigated, Grable and Sarpy soils are better suited to small grain and pasture and hay. This association has a good potential for irrigation, and in most areas adequate water can be obtained from shallow wells.

7. *Calco-Kennebec association*

Deep, poorly drained and moderately well drained, level and nearly level, silty soils

This soil association is on bottom lands along Brule Creek and its tributaries. Slopes are long and plane. Some areas are broken by stream channels and meander scars.

This association makes up about 4 percent of the county. It is about 70 percent Calco soils, 10 percent Kennebec soils, and 20 percent minor soils.

Calco soils are level and poorly drained. The surface layer is calcareous, dark gray silty clay loam. The underlying material is calcareous, dark gray and gray silty clay loam.

Kennebec soils are nearly level and moderately well drained. The surface layer is dark gray silty clay loam. Below that, to a depth of 50 inches, is dark grayish brown and grayish brown silty clay loam. Below that is grayish brown loam.

The minor soils in this association are Alcester and Storla

soils on foot slopes and fans on the edges of bottom lands; Benclare, Lamo, and McPaul soils scattered throughout the area; and Dempster soils on terraces.

The major soils have high fertility, are subject to flooding, and have a seasonal high water table. Wetness limits the use of Calco soils for crops, but Kennebec soils have only slight limitations for crops.

Most of this association is used for pasture or hay. Drainage improvement is not feasible in many areas of the poorly drained Calco soils. Some better drained soils are used for corn, soybeans, and alfalfa, but much of the association is better suited to pasture and hay.

8. Kennebec-Fluvaquents-Benclare association

Deep, moderately well drained to very poorly drained, level and nearly level, silty and mixed sandy to clayey soils

This association is on the bottom lands of the Big Sioux River. Slopes are mostly nearly level or level, but some are broken by swales or former stream channels and meander scars.

This association makes up about 7 percent of the county. It is about 50 percent Kennebec soils, 15 percent Fluvaquents, 10 percent Benclare soils, and 25 percent minor soils.

Kennebec soils are nearly level and moderately well drained. The surface layer is dark gray silty clay loam. Below that is dark grayish brown and grayish brown silty clay loam. Grayish brown loam is at a depth of 50 inches.

Fluvaquents are mixed alluvial soils in former stream channels or within the oxbows of the present river channel. These soils are level to nearly level and somewhat poorly drained to very poorly drained. The surface layer ranges from loamy sand to clay. The underlying material is sandy to clayey and is stratified by contrasting textures.

Benclare soils are level and somewhat poorly drained. The surface layer is mostly dark gray silty clay loam, but many areas have an overwash of grayish brown silt loam, very fine sandy loam, or silty clay loam. The subsoil is dark gray silty clay loam and silty clay. The underlying material is grayish brown silty clay and silty clay loam.

The minor soils in this association are Alcester soils on foot slopes on the edges of the stream valleys, Davis and Salix soils on high bottoms several feet above the major soils, and Luton soils on the lower parts of the bottoms.

Fertility and organic-matter content are high in most of this association, but Fluvaquents have low to high fertility and organic-matter content. Permeability ranges from moderate in Kennebec soils to slow in Benclare soils. The available water capacity is high. Wetness from flooding and from a seasonal water table affects the use of Benclare soils and Fluvaquents for crops, but Kennebec soils have only slight limitations for crops.

Most of this association has a high potential for all crops grown in the county, but frequently flooded Fluvaquents are better suited to pasture and wildlife habitat. Corn, soybeans, and alfalfa are the main crops.

9. Albaton-Haynie-Onawa association

Deep, poorly drained to well drained, level and nearly level, clayey and silty soils

This soil association is on low-lying bottom lands of the Missouri River. Slopes are level and nearly level and are broken by numerous former stream channels and meander scars.

This association makes up about 10 percent of the county. It is about 35 percent Albaton soils, 25 percent Haynie soils, 20 percent Onawa soils, and 20 percent minor soils.

Albaton soils are level and poorly drained. They are on lower parts of the landscape, many of which are former stream channels. The surface layer and underlying material are calcareous, grayish brown silty clay, but some areas have an overwash of silt loam on the surface.

Haynie soils are level to nearly level and are moderately well drained to well drained. They are on slightly higher levels between the former stream channels. The surface layer commonly is calcareous, light brownish gray silt loam, but in some places an overwash of silty clay loam is on the surface. The underlying material is calcareous, light brownish gray silt loam and very fine sandy loam.

Onawa soils are level and are somewhat poorly drained to poorly drained. They commonly are on broad flats, but some are in swales or former stream channels. The surface layer is calcareous, grayish brown silty clay. The underlying material is calcareous, light brownish gray and gray silty clay. Calcareous, light gray silt loam is at a depth of 25 inches.

The minor soils in this association are Grable, Modale, and Sarpy soils on the higher parts of bottoms and Percival soils on the lower parts. Fluvaquents and intermittent lakes are in some more deeply entrenched former stream channels.

The major soils mostly have medium fertility but have moderately low organic-matter content. The available water capacity ranges from low or moderate in Albaton soils to high in Haynie soils. In some years wetness from a seasonal water table and flooding delays farming. Improving drainage and maintaining tilth and fertility are the main concerns of management.

Most of this association is cultivated. Some areas are irrigated. Corn, soybeans, and alfalfa are the main crops. If adequately drained, this association has a high potential for crops. A few areas remain in native vegetation and are used for pasture and hay.

10. Forney-Luton association

Deep, poorly drained, level, clayey soils

This soil association is on bottom lands at the confluence of the Big Sioux and Missouri Rivers. Slopes are nearly level.

This association makes up about 12 percent of the county. It is about 45 percent Forney soils, 25 percent Luton soils, and 30 percent minor soils.

Forney soils have a surface layer and subsoil of gray and dark gray silty clay that extends to a depth of 21 inches. Next is a layer of very dark gray and dark gray silty clay. Below this is gray silty clay.

Luton soils are slightly below Forney soils. The surface layer is very dark gray and black silty clay. The subsoil is very dark gray, dark gray, and olive gray silty clay. The underlying material is calcareous, olive gray and gray silty clay.

The minor soils in this association are Benclare, Blencoe, and Lakeport soils in slightly higher areas of the association.

The major soils have high fertility. Permeability is very slow, and the soils dry slowly. Wetness from a seasonal high water table commonly delays planting in spring. Some areas are subject to flooding. If farmed when wet, these soils compact and lose their tilth. Improving drainage, providing protection from flooding, and maintaining tilth are the main concerns of management.

Most areas are cultivated. These soils are best suited to

late-planted crops such as corn and soybeans. Alfalfa and winter wheat also are grown.

11. Modale-Blyburg-Benclare association

Deep, well drained to somewhat poorly drained, nearly level and level, silty soils

This soil association is on bottom lands of the Big Sioux and Missouri Rivers. The terrain appears flat and is broken only by shallow swales and low spots.

This association makes up about 9 percent of the county. It is about 20 percent Modale soils, 15 percent Blyburg soils, 15 percent Benclare soils, and 50 percent minor soils.

Modale soils are nearly level and moderately well drained. The surface layer is calcareous, grayish brown silt loam. The underlying material is calcareous, light brownish gray silt loam and very fine sandy loam to a depth of 24 inches. Below this it is calcareous, light brownish gray silty clay.

Blyburg soils are nearly level and well drained. The surface layer is grayish brown silt loam. The underlying material is calcareous, light brownish gray silt loam.

Benclare soils are level and somewhat poorly drained. The surface layer is dark gray silty clay loam, but in some areas it has a recent overwash of grayish brown silt loam. The subsoil is dark gray silty clay loam and silty clay. The underlying material is grayish brown silty clay and silty clay loam.

The minor soils in this association are Albaton, Blencoe, Forney, Haynie, Lakeport, Omadi, and Salix soils. They are generally in swales and on the lower parts of the landscape.

The major soils in this association have medium to high fertility. The available water capacity is moderate to high. Permeability is moderate in Blyburg soils and in the upper part of Modale soils, but it is slow in Benclare soils. Blyburg and Modale soils have only slight limitations for crops, but in some years farming on Benclare soils is delayed because of wetness from a seasonal high water table or flooding. Maintaining fertility is the main concern of management, and overcoming wetness and maintaining tilth are also major concerns on Benclare soils.

Most of this association is used for corn, soybeans, and alfalfa. The soils are well suited to all crops grown in the county. Blyburg and Modale soils have a good potential for irrigation, and in most areas, adequate water can be obtained from shallow wells.

Descriptions of the Soils

This section describes each soil series in detail and then, briefly, each mapping unit in that series. Unless stated otherwise, what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface down to rock or other underlying material. The profile of each series is described twice. The first description is brief and in terms familiar to the layman. The second is more detailed and is for those who need to make thorough and precise studies of soils. The profile described is representative of mapping units in a series. If the profile of a given mapping unit is different from that of the series, the differences are apparent in the name of the mapping unit or are stated in describing the mapping unit. Color terms are for dry soil unless otherwise stated.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Fluvaquents, for example, does not belong to a soil series. Nevertheless it is listed in alphabetic order along with the soil series.

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, pasture group, and windbreak group in which the mapping unit has been placed. The page where each capability unit is described is listed in "Guide to Mapping Units" at the back of this survey.

The approximate acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*7*).[1]

Albaton Series

The Albaton series consists of deep, poorly drained, level, calcareous, clayey soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses, sedges, and water-tolerant trees.

In a representative profile the surface layer is calcareous, grayish brown silty clay about 7 inches thick. The underlying material also is calcareous, grayish brown silty clay.

Albaton soils have moderately low organic-matter content and medium fertility. Permeability is slow or very slow, and the available water capacity is low or moderate. These soils have a seasonal water table at a depth of 1 to 3 feet and commonly receive runoff from adjacent soils.

Most areas are used for crops. A few areas remain in native vegetation or have been seeded to tame grasses and are used for pasture, hay, or wildlife habitat.

Representative profile of Albaton silty clay, in cultivation, 108 feet east and 12 feet north of the center of sec. 11, T. 89 N., R. 49 W.

Ap—0 to 7 inches; grayish brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) moist; weak medium blocky structure parting to moderate very fine blocky; very hard, firm, sticky and plastic; few black and very dark brown organic stains; slight effervescence; mildly alkaline; abrupt smooth boundary.

C1g—7 to 16 inches; grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; few medium distinct strong brown (7.5YR 5/6) mottles, moist, and few fine faint gray mottles, moist; weak medium subangular blocky structure parting to moderate fine and very fine subangular blocky; very hard, very firm, sticky and plastic; strong effervescence; mildly alkaline; gradual smooth boundary.

C2g—16 to 60 inches; grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; many coarse distinct dark gray (5Y 4/1) and very dark gray (5Y 3/1) mottles, moist; common fine distinct strong brown (7.5YR 5/6) mottles, moist; few fine prominent black (5YR 2/1) mottles, moist; horizontal laminations evident, some layers have strong fine and very fine blocky structure; extremely hard, extremely firm, very sticky and very plastic; few thin lenses of silt loam at a depth of about 3 feet; shiny pressure faces on peds and cleavage planes; slight effervescence; mildly alkaline.

[1] Italic numbers in parentheses refer to Literature Cited, p. 85.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Area	Extent
Albaton silt loam, overwash	930	0.3
Albaton silty clay	7,800	2.7
Albaton silty clay, depressional	1,450	.5
Alcester silty loam, 2 to 6 percent slopes	27,490	9.5
Benclare silty clay loam, somewhat poorly drained	4,150	1.4
Benclare soils, overwash	1,320	.5
Blencoe silty clay	2,500	.9
Blyburg silt loam	4,150	1.4
Calco silty clay loam, wet	9,710	3.4
Crofton silt loam, 12 to 17 percent slopes, eroded	11,320	3.9
Crofton silt loam, 17 to 30 percent slopes	2,400	.8
Crofton-Nora silt loams, 2 to 6 percent slopes	1,500	.5
Crofton-Nora silt loams, 6 to 12 percent slopes, eroded	37,190	12.9
Davis loam	1,500	.5
Dempster silty clay loam	1,960	.7
Egan-Shindler complex, 2 to 6 percent slopes	4,200	1.5
Egan-Shindler complex, 6 to 9 percent slopes	1,300	.5
Enet loam, 0 to 2 percent slopes	700	.2
Enet and Dempster soils, 2 to 6 percent slopes	480	.2
Fluvaquents	2,600	.9
Fluvaquents, wet	3,450	1.2
Forney silty clay	15,730	5.4
Forney soils, overwash	1,260	.4
Grable silt loam	3,150	1.1
Graceville silty clay loam	2,600	.9
Haynie silt loam	7,250	2.5
Haynie silty clay loam	2,300	.8
James silty clay	420	.1
Kennebec silty clay loam	12,220	4.2
Lakeport silty clay loam	2,300	.8
Lamo silty clay loam	2,900	1.0
Luton silty clay	9,510	3.3
McPaul silt loam	8,500	3.0
Modale silt loam	5,600	1.9
Moody silty clay loam, 0 to 2 percent slopes	200	[1]
Moody silty clay loam, 2 to 6 percent slopes	11,020	3.8
Moody-Nora silty clay loams, 6 to 10 percent slopes	14,320	5.0
Nora-Crofton silt loams, 20 to 50 percent slopes	610	.2
Omadi silt loam	3,450	1.2
Onawa silty clay	6,500	2.3
Percival silty clay	1,400	.5
Salix silty clay loam	3,200	1.1
Salmo silty clay loam, somewhat poorly drained	780	.3
Sarpy loamy fine sand, 3 to 9 percent slopes	2,800	1.0
Sarpy silty clay overwash, 0 to 1 percent slopes	720	.3
Sarpy soils, 0 to 3 percent slopes	2,900	1.0
Shindler clay loam, 9 to 15 percent slopes	1,330	.5
Shindler clay loam, 15 to 30 percent slopes	1,000	.3
Storla loam	720	.3
Thurman fine sandy loam, 3 to 9 percent slopes	670	.2
Wakonda-Worthing-Chancellor complex	11,820	4.1
Wentworth silty clay loam, 0 to 2 percent slopes	8,950	3.1
Wentworth silty clay loam, 2 to 6 percent slopes	4,150	1.4
Wentworth-Worthing silty clay loams	4,300	1.5
Whitewood silty clay loam	1,230	.4
Worthing silty clay loam	1,000	.3
Worthing-Chancellor silty clay loams	2,950	1.0
Water (less than 40 acres in size)	370	.1
Intermittent lake	270	.1
Gravel pits	496	.2
Made land	70	[1]
Borrow pits	100	[1]
Lagoons	50	[1]
Total land area	289,216	100.0
Water (more than 40 acres in size)	9,024	
Total area	298,240	

[1] Less than 0.1 percent.

Albaton soils are silty clay or clay between depths of 10 and 40 inches. The A horizon typically ranges from grayish brown to dark gray in a hue of 2.5Y or 10YR, but in places the recent overwash is light brownish gray. The A horizon commonly is silty clay less than 10 inches thick, but in places it is silt loam or silty clay loam. The Cg horizon ranges from olive gray to grayish brown in a hue of 2.5Y or 5Y. Thin lenses of slit loam to fine sand are in the Cg horizon in many pedons. A thin buried A horizon is in the Cg horizon in places. Stratified sand and silt are at a depth of 40 to 60 inches in some pedons. The Cg horizon is mildly alkaline or moderately alkaline.

Albaton soils are near Forney, Grable, Haynie, Onawa, Percival, and Sarpy soils. Albaton soils are calcareous nearer the surface than Forney soils. They are more clayey and more poorly drained than Grable, Haynie, and Sarpy soils. They are clayey to a greater depth than Onawa and Percival soils.

Ab—Albaton silt loam, overwash. This is a level soil on wide bottom lands in areas up to 500 acres in size. Slopes are 0 to 1 percent. This soil commonly has an overwash of light brownish gray silt loam 5 to 15 inches thick. Some low areas have no overwash layer and have a surface layer of silty clay. Included in mapping are small areas of Modale soils on very slight rises.

Because runoff is slow and the water table is seasonally high, wetness is a problem in some years. Although water accumulates in the underlying clayey layers following intensive rains, the surface layer dries quickly and farming is delayed for only short periods.

Most areas are cultivated. This soil is well suited to most crops grown in the county. Capability unit IIw-1, pasture group A, windbreak group 2.

Ac—Albaton silty clay. This is a level soil on bottom lands. The areas are mostly long and narrow and less than 200 acres in size, but a few broad areas range to 400 acres. This soil has the profile described as representative of the series. Slopes are 0 to 1 percent.

Included with this soil in mapping are small areas of Onawa and Percival soils on very slight rises.

Runoff is slow. This soil dries slowly, and wetness caused by the high water table commonly delays farming in spring. If farmed when wet, this soil compacts and loses its tilth. Overcoming wetness and maintaining tilth are the main concerns of management.

Most areas are used for corn, soybeans, and alfalfa. If adequately drained, this soil is well suited to late-planted crops. Capability unit IIIw-2, pasture group A, windbreak group 2.

Ad—Albaton silty clay, depressional. This is a level soil in former stream channels that are entrenched several feet below the adjacent bottom lands. Slopes are 0 to 1 percent. The areas are long and narrow and are mostly less than 80 acres in size. This soil has a profile similar to the one described as representative of the series, but in areas

along the Big Sioux River the surface layer is darker and contains slightly less clay.

Runoff accumulates on this soil and remains ponded until it evaporates. The water table usually is high during the early part of the growing season.

This soil is too wet for farming in most years and is better suited to pasture, hay, or wildlife habitat. A few areas are cropped in drier years, but in most areas improved drainage is not feasible. The vegetation in undisturbed areas consists mainly of slough sedge, reedgrasses, and rushes. Capability unit Vw-2, pasture group B, windbreak group 10.

Alcester Series

The Alcester series consists of deep, moderately well drained, gently sloping, silty soils on uplands along intermittent drainageways. These soils formed in alluvium washed from adjacent upland soils. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is dark grayish brown silt loam about 15 inches thick. The subsoil is silt loam about 27 inches thick. It is dark grayish brown in the upper 19 inches and grayish brown in the lower 8 inches. The underlying material is light brownish gray light silty clay loam. It is calcareous below a depth of 50 inches.

Alcester soils have high fertility and low organic-matter content. Permeability is moderate, and the available water capacity is high. These soils receive additional moisture in the form of runoff from adjacent soils.

Almost all areas are used for crops. A few areas are used for grazing or hay.

Representative profile of Alcester silt loam, 2 to 6 percent slopes, in cultivation, 270 feet south and 2,020 feet west of the northeast corner of sec. 34, T. 95 N., R. 49 W.

Ap—0 to 7 inches; dark grayish brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak fine granular structure; hard, friable; neutral; abrupt smooth boundary.

A12—7 to 15 inches; dark grayish brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) moist; weak thick platy structure parting to weak coarse subangular blocky; slightly hard, very friable; neutral; gradual wavy boundary.

B1—15 to 24 inches; dark grayish brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) crushing to very dark grayish brown (10YR 3/2) moist; weak coarse and medium subangular blocky structure; slightly hard, very friable; neutral; gradual wavy boundary.

B2—24 to 34 inches; dark grayish brown (2.5Y 4/2) silt loam, very dark grayish brown (10YR 3/2) crushing to dark brown (10YR 3/3) moist; weak medium prismatic structure parting to weak medium subangular blocky; hard, friable; few darker colored worm casts; neutral; gradual wavy boundary.

B3—34 to 42 inches; grayish brown (2.5Y 5/2) silt loam, dark grayish brown (2.5Y 4/2) moist; weak coarse and medium subangular blocky structure; hard, friable; few darker colored worm casts; neutral; gradual wavy boundary.

C1—42 to 50 inches; light brownish gray (2.5Y 6/2) light silty clay loam, dark grayish brown (10YR 4/2) moist; few fine distinct gray (5Y 5/1) and yellowish brown (10YR 5/6) mottles, moist; weak coarse subangular blocky structure; hard, friable, slightly sticky; neutral; gradual wavy boundary.

C2—50 to 60 inches; light brownish gray (2.5Y 6/2) light silty clay loam, dark grayish brown (2.5Y 4/2) moist; few fine distinct dark gray (5Y 4/1) and strong brown (7.5YR 5/6) mottles, moist; massive; hard, friable, slightly sticky; few fine and medium segregations of lime; slight effervescence; mildly alkaline.

Depth to lime ranges from 40 to 60 inches, but in places calcareous, recent overwash is on the surface. The solum is light silty clay loam or silt loam and averages about 24 to 30 percent clay. The A horizon ranges from very dark gray to dark grayish brown and is 14 to 22 inches thick. The upper part of the B horizon ranges from very dark gray to dark grayish brown. The lower part ranges from dark gray to light olive brown in a hue of 10YR or 2.5Y. The C horizon typically is light silty clay loam or silt loam, but in places it is loam at a depth of 40 to 60 inches.

Alcester soils are near Calco, Crofton, Davis, Kennebec, Lamo, McPaul, Moody, and Nora soils. Alcester soils are better drained than Calco and Lamo soils. They have a thicker A horizon than Crofton, McPaul, Moody, and Nora soils. Alcester soils are more silty than Davis soils. They have a thinner A horizon and are shallower to free carbonates than Kennebec soils.

Ae—Alcester silt loam, 2 to 6 percent slopes. This is a gently sloping soil on narrow strips along upland drainageways. Most areas are less than 60 acres in size. Slopes are mostly concave.

Included with this soil in mapping are small areas of Kennebec, McPaul, and Moody soils. Kennebec soils are on the lower parts of the landscape adjacent to drainage channels. McPaul soils are in places where recent overwash has accumulated along fencelines or roadsides. Moody soils are on the higher parts of the landscape, generally along the edges of the mapped area.

Runoff is medium, and the hazard of erosion is moderate. Gullies form easily in the drainageway channels. Controlling erosion is the main concern of management.

This soil is well suited to all crops commonly grown in the county. Capability unit IIe-1, pasture group K, windbreak group 1.

Benclare Series

The Benclare series consists of deep, somewhat poorly drained, level, silty soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is dark gray silty clay loam about 16 inches thick. The subsoil is about 20 inches thick. It is dark gray silty clay loam in the upper part and dark gray silty clay in the lower part. The underlying material is grayish brown silty clay and silty clay loam.

Benclare soils have moderate to high organic-matter content and high fertility. Permeability is slow, and the available water capacity is high. These soils are occasionally flooded and have a seasonal water table at a depth of 3 to 6 feet.

Most areas are used for crops. A few areas are used for pasture and hay.

Representative profile of Benclare silty clay loam, somewhat poorly drained, in cultivation, 1,230 feet west and 2,450 feet south of the northeast corner of sec. 25, T. 93 N., R. 49 W.

Ap—0 to 7 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak fine subangular blocky structure; hard, friable, slightly sticky and slightly plastic; slightly acid; abrupt smooth boundary.

A12—7 to 16 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak medium and fine subangular blocky structure; hard, friable, slightly sticky and slightly plastic; slightly acid; gradual wavy boundary.

B21—16 to 26 inches; dark gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) moist; weak medium prismatic structure parting to moderate medium and fine subangular blocky; hard, friable, sticky and plastic; slightly acid; gradual wavy boundary.

B22—26 to 36 inches; dark gray (10YR 4/1) silty clay, very dark gray (10YR 3/1) moist; few fine distinct strong brown (7.5YR 5/6) mottles, moist; weak medium prismatic

structure parting to moderate medium and fine subangular blocky; very hard, firm, sticky and plastic; slightly acid; gradual wavy boundary.

C1—36 to 48 inches; grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; common fine distinct strong brown (7.5YR 5/6) and few fine faint dark gray mottles, moist; massive; very hard, firm, sticky and plastic; slightly acid; gradual wavy boundary.

C2—48 to 60 inches; grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; common fine distinct strong brown (7.5YR 5/6) and dark reddish brown (5YR 2/2) mottles, moist, and many medium faint dark gray mottles, moist; massive; very hard, firm, sticky and plastic; slightly acid.

Depth to free carbonates is 40 to 60 inches or more. The A horizon is dark gray or very dark gray except in places that have a grayish brown overwash. It is dominantly silty clay loam, but in places it is light silty clay, silt loam, or very fine sandy loam. It is 10 to 20 inches thick. The B2 horizon ranges from 18 to 30 inches in thickness. Some pedons have a B3 horizon. Thin lenses of fine sand are in the C horizon in places.

Benclare soils are near Blencoe, Davis, Forney, Kennebec, Luton, and Salix soils and are similar to the Lakeport soils. Benclare soils have a more clayey C horizon than Blencoe soils. They are more poorly drained and have a more clayey B horizon than Davis, Kennebec, and Salix soils. Benclare soils are not so poorly drained as Forney and Luton soils. They have moist colors of very dark gray or darker to a greater depth than Lakeport soils.

Bd—Benclare silty clay loam, somewhat poorly drained. This is a level soil on bottom lands in areas as much as 500 acres in size. It has the profile described as representative of the series. Slopes are 0 to 1 percent.

Included with this soil in mapping are small areas of Kennebec and Luton soils. Kennebec soils are on very slight rises. Luton soils are in low areas.

Runoff is slow. This Benclare soil has high fertility and organic-matter content. Wetness that results from occasional flooding and from a fluctuating water table is the main limitation in using this soil for crops. If cultivated when wet, the surface layer compacts and easily loses its tilth.

Most areas are cultivated. If adequately drained, this soil is well suited to all crops commonly grown in the county. Capability unit IIw-1, pasture group A, windbreak group 2.

Be—Benclare soils, overwash. These soils are on bottom lands, mainly along the Big Sioux River. Slopes are 0 to 1 percent. Most areas are covered by 5 to 15 inches of recent overwash of grayish brown, calcareous silt loam, very fine sandy loam, or silty clay loam. Some low areas have no overwash and have a surface layer of dark gray silty clay loam.

Included with these soils in mapping are small areas of Modale soils on very slight rises.

These Benclare soils have moderate organic-matter content and high fertility. Runoff is slow, and the areas are subject to flooding. Wetness caused by flooding and a seasonal high water table is the main limitation in using these soils for crops. Farming is delayed for only brief periods, however, because the overwash surface layer dries quickly.

Most areas are cultivated, and a few areas are irrigated. If adequately drained, these soils are well suited to all crops commonly grown in the county. Capability unit IIw-1, pasture group A, windbreak group 2.

Blencoe Series

The Blencoe series consists of deep, somewhat poorly drained, level, clayey soils that are underlain by stratified silty sediments. These soils are on high stream bottoms. They formed in alluvium. The native vegetation consisted mainly of tall grasses and scattered clumps of trees.

In a representative profile the surface layer is dark gray silty clay about 12 inches thick. The subsoil is about 16 inches thick. It is grayish brown and dark grayish brown silty clay in the upper 12 inches and grayish brown and light brownish gray light silty clay loam in the lower 4 inches. The underlying material is calcareous, light yellowish brown silt loam and silty clay loam.

Blencoe soils have high fertility and high organic-matter content. Permeability is very slow in the upper part of the profile and moderate in the underlying material. The available water capacity is high. Blencoe soils have a seasonal water table at a depth of 1 to 3 feet. Some areas are subject to flooding.

Most areas are cultivated, and a few are irrigated. Some areas are used for pasture and hay.

Representative profile of Blencoe silty clay, in cultivation, 87 feet west and 1,480 feet north of the southeast corner of sec. 16, T. 91 N., R. 50 W.

Ap—0 to 8 inches; dark gray (10YR 4/1) silty clay, black (10YR 2/1) moist; weak fine blocky structure; very hard, firm, sticky and plastic; slightly acid; abrupt smooth boundary.

A12—8 to 12 inches; dark gray (10YR 4/1) silty clay, black (10YR 2/1) moist; moderate fine and very fine blocky structure; very hard, firm, sticky and plastic; slightly acid; gradual smooth boundary.

B1—12 to 16 inches; grayish brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) moist; weak medium subangular blocky structure parting to moderate fine and very fine subangular blocky; hard, firm, sticky and plastic; common black (10YR 2/1) channel fillings and worm casts, moist; neutral; gradual smooth boundary.

B2—16 to 24 inches; grayish brown (2.5Y 5/2) and dark grayish brown (2.5Y 4/2) silty clay, very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2) moist; few fine faint dark brown mottles, moist; moderate fine and very fine subangular blocky structure; hard, firm, sticky and plastic; few very dark gray (10YR 3/1) streaks, moist; neutral; gradual smooth boundary.

IIB3—24 to 28 inches; grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) light silty clay loam, dark grayish brown (2.5Y 4/2) moist; common fine distinct strong brown (7.5YR 5/6) mottles, moist; weak fine subangular blocky structure; hard, friable, slightly sticky and plastic; few very dark gray (10YR 3/1) streaks, moist; neutral; gradual smooth boundary.

IIC1—28 to 55 inches; light yellowish brown (2.5Y 6/3) silt loam, grayish brown (2.5Y 5/2) moist; many fine distinct strong brown (7.5YR 5/6) mottles, moist, and many medium faint gray mottles, moist; massive, laminations evident; soft, very friable; strong effervescence; mildly alkaline; abrupt smooth boundary.

IIC2—55 to 60 inches; light yellowish brown (2.5Y 6/3) silty clay loam, light olive brown (2.5Y 5/3) moist; many fine faint gray mottles, moist, and many fine distinct strong brown (7.5YR 5/6) mottles, moist; massive; hard, firm, slightly sticky and plastic; strong effervescence; mildly alkaline.

Blencoe soils are dominantly silty clay to a depth of 20 to 30 inches and are underlain by silt loam to a depth of 40 inches or more. The A horizon is dark gray or very dark gray, and in places it is silty clay loam. It is 10 to 20 inches thick. The upper part of the B horizon is silty clay that averages 42 to 50 percent clay. The lower part of the B horizon commonly is silt loam or silty clay loam, but in places it is silty clay. Thin lenses of finer or coarser material are in the IIC horizon in some pedons.

Blencoe soils are near Blyburg, Forney, Lakeport, Luton, Omadi, and Salix soils and are similar to Onawa soils. Blencoe soils are more clayey than Blyburg, Omadi, and Salix soils. They have a more silty C horizon than Forney, Lakeport, and Luton soils. They have a thicker A horizon than Onawa soils.

Bf—Blencoe silty clay. This is a level soil on bottom lands along larger streams. Slopes are 0 to 1 percent. Most areas are long and narrow and are less than 100 acres in size. In some small areas the depth to silty material is slightly less

than 20 inches. Included in mapping are small areas of Forney and Lakeport soils intermingled with the Blencoe soil.

Runoff is slow, and flooding is a hazard in some areas. Wetness caused by a seasonal high water table is the main limitation in using this soil for crops. It delays farming in some years. If farmed when wet, this soil compacts and easily loses its tilth.

Most areas are used for crops. If adequately drained, this soil is well suited to farming. Capability unit IIw-1, pasture group A, windbreak group 2.

Blyburg Series

The Blyburg series consists of deep, well drained, nearly level, silty soils on high stream bottoms. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is grayish brown silt loam about 11 inches thick. The underlying material is calcareous, light brownish gray silt loam.

Blyburg soils have high fertility and high organic-matter content. Permeability is moderate, and the available water capacity is high.

Most areas are cultivated. A few areas are irrigated.

Representative profile of Blyburg silt loam, in cultivation, 1,500 feet north and 129 feet west of the southeast corner of sec. 23, T. 90 N., R. 49 W.

Ap—0 to 6 inches; grayish brown (10YR 5/2) silt loam, very dark brown (10YR 2/2) moist; weak fine granular structure; slightly hard, very friable; neutral; abrupt smooth boundary.

A12—6 to 11 inches; grayish brown (10YR 5/2) silt loam, very dark brown (10YR 2/2) moist; weak fine granular structure; slightly hard, very friable; neutral; clear smooth boundary.

C1—11 to 19 inches; light brownish gray (2.5Y 6/2) silt loam, grayish brown (2.5Y 5/2) moist; weak coarse and medium subangular blocky structure; soft, very friable; few worm channels and casts, very dark brown (10YR 2/2) moist; common fine pores; strong effervescence; mildly alkaline; gradual smooth boundary.

C2—19 to 60 inches; light brownish gray (2.5Y 6/2) silt loam, grayish brown (2.5Y 5/2) moist; few fine distinct light olive brown (2.5Y 5/6) mottles, moist; massive, laminations evident; soft, very friable; strong effervescence; mildly alkaline.

Depth to lime ranges from 10 to 15 inches. The A horizon is grayish brown or dark grayish brown. It commonly is silt loam, but in places it is silty clay loam. It is 10 to 20 inches thick. The C horizon is light brownish gray or grayish brown in a hue of 10YR or 2.5Y. It is silt loam or very fine sandy loam.

Blyburg soils are near Blencoe, Forney, Lakeport, Luton, Omadi, and Salix soils and are similar to Haynie soils. Blyburg soils are better drained and less clayey than Blencoe, Forney, Lakeport, and Luton soils. They have a thicker A horizon than Haynie soils. They contain less clay in the C horizon than Omadi and Salix soils.

Bg—Blyburg silt loam. This is a nearly level soil on high bottoms. Slopes are 0 to 2 percent. The areas are irregularly shaped and range to 400 acres in size. The surface layer is mostly silt loam, but it is silty clay loam or silty clay in some low areas that have a thin overwash layer on the surface.

Included with this soil in mapping are small areas of Modale and Omadi soils in swales and low spots.

Runoff is slow. This soil is easy to work and has few if any limitations for cropping.

Most areas are cropped, and a few areas are irrigated. This soil is well suited to all crops commonly grown in the county. Capability unit I-1, pasture group F, windbreak group 3.

Calco Series

The Calco series consists of deep, poorly drained, level, calcareous, silty soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses, sedges, and stringers of native trees along stream channels.

In a representative profile the surface layer is calcareous, dark gray silty clay loam about 39 inches thick. The underlying material is calcareous silty clay loam. It is dark gray to a depth of 47 inches and gray below.

Calco soils have high fertility and high organic-matter content. Permeability is moderately slow, and the available water capacity is high. These soils are occasionally flooded and have a seasonal high water table within 3 feet of the surface.

Most areas are in pasture or hayland. A few areas that have been successfully drained are used for crops.

Representative profile of Calco silty clay loam, wet, in cultivation, 115 feet north and 2,380 feet east of the southwest corner of sec. 12, T. 94 N., R 50 W.

Ap—0 to 8 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; moderate fine subangular blocky structure; hard, friable, sticky and slightly plastic; strong effervescence; moderately alkaline; abrupt smooth boundary.

A12—8 to 18 inches; dark gray (2.5Y 4/1) light silty clay loam, black (N 2/0) moist; weak medium and fine subangular blocky structure; hard, friable, sticky and slightly plastic; few fragments of snail shells; strong effervescence; moderately alkaline; gradual wavy boundary.

A13—18 to 27 inches; dark gray (2.5Y 4/1) silty clay loam, black (N 2/0) moist; weak medium and fine subangular blocky structure; very hard, firm, sticky and plastic; few fragments of snail shells; strong effervescence; mildly alkaline; gradual wavy boundary.

A14—27 to 39 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak coarse subangular blocky structure parting to moderate medium subangular blocky; very hard, very firm, sticky and plastic; strong effervescence; moderately alkaline; gradual wavy boundary.

C1g—39 to 47 inches; dark gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) moist; few fine faint olive gray mottles, moist; massive; extremely hard, very firm, sticky and plastic; many fine segregations of lime; strong effervescence; mildly alkaline; gradual wavy boundary.

C2g—47 to 60 inches; gray (10YR 6/1) silty clay loam, dark gray (10YR 4/1) moist; common fine distinct olive (5Y 4/3) and very dark brown (10YR 2/2) mottles, moist, and few fine distinct dark yellowish brown (10YR 4/4) mottles, moist; massive; extremely hard, very firm, sticky and plastic; few fine gypsum crystals; many fine and medium concretions of lime; strong effervescence; moderately alkaline.

Calco soils commonly are calcareous at the surface, but some pedons are leached to a depth of 5 to 10 inches. Some pedons have a B horizon. The A horizon commonly is silty clay loam, but in places it is silt loam. It is 28 to 40 inches thick. The C horizon is silty clay or silty clay loam, and in places it is stratified with thin layers of sand.

Calco soils are near Alcester, Benclare, Kennebec, and McPaul soils, and are similar to Lamo soils. Calco soils are more poorly drained than the other soils.

Ca—Calco silty clay loam, wet. This soil is on bottom lands along streams and small drainageways. Slopes are 0 to 1 percent. The areas along drainageways are long and narrow, but broader areas on stream bottoms are as much as 1,000 acres in size. This soil has a profile similar to the one described as representative of the series, but in some long, narrow areas it has a thin overwash layer of grayish brown silt loam on the surface.

Included with this soil in mapping are small areas of Alcester and Kennebec soils on the edges of areas immediately below the adjacent upland soils. Also included are a few small areas of Fluvaquents, wet, along Brule Creek.

Runoff is slow, and most areas are subject to occasional flooding. Wetness caused by flooding and the high water table severely limits the use of this soil for crops. The surface layer compacts if the soil is farmed or grazed when wet. Overcoming wetness is the main concern of management.

This soil is best suited to pasture or hay plants that tolerate wetness. In some years late crops can be grown successfully. Measures to improve drainage are not feasible in most places. Capability unit IVw-2, pasture group B, windbreak group 2.

Chancellor Series

The Chancellor series consists of deep, somewhat poorly drained, nearly level, silty soils on uplands in swales and depressions. These soils formed in alluvium washed from surrounding soils. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is dark gray silty clay loam about 17 inches thick. The subsoil is about 21 inches thick. It is dark gray silty clay in the upper part, grayish brown silty clay in the middle, and light olive gray silty clay loam in the lower part. The underlying material is calcareous, light yellowish brown and gray silty clay loam.

Chancellor soils have high fertility and high organic-matter content. Permeability is slow, and the available water capacity is high. Most areas receive additional moisture in the form of runoff from adjacent soils. A seasonal water table is at a depth of 2 to 5 feet.

Most areas are cultivated. Chancellor soils are well suited to all crops commonly grown in the county.

Chancellor soils in Union County are mapped only with Wakonda and Worthing soils.

Representative profile of Chancellor silty clay loam, in an area of Worthing-Chancellor silty clay loam, in cultivation, 510 feet north and 1,050 feet west of the southeast corner of sec. 15, T. 92 N., R. 50 W.

Ap—0 to 6 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak medium and fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; neutral; abrupt smooth boundary.

A12—6 to 17 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak coarse subangular blocky structure parting to weak medium and fine subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; slightly acid; gradual wavy boundary.

B21t—17 to 27 inches; dark gray (5Y 4/1) silty clay, black (5Y 2/1) moist; few fine distinct strong brown (7.5YR 5/6) and light olive brown (2.5Y 5/4) mottles, moist; weak medium prismatic structure parting to moderate medium and fine subangular blocky; very hard, firm, sticky and plastic; neutral; gradual wavy boundary.

B22tg—27 to 33 inches; grayish brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) moist; many fine distinct strong brown (7.5YR 5/6) and light olive brown (2.5Y 5/4) mottles, moist; weak coarse prismatic structure parting to weak coarse subangular blocky; hard, firm, sticky and plastic; neutral; gradual wavy boundary.

B3g—33 to 38 inches; light olive gray (5Y 6/2) silty clay loam, olive gray (5Y 5/2) moist; many fine distinct dark gray (5Y 4/1) and strong brown (7.5YR 5/6) mottles, moist; weak coarse subangular blocky structure; hard, firm, sticky and plastic; neutral; clear wavy boundary.

Cgca—38 to 60 inches; light yellowish brown (2.5Y 6/3) and gray (5Y 5/1) silty clay loam, light olive brown (2.5Y 5/3) and dark gray (5Y 4/1) moist; many fine distinct strong brown (7.5YR 5/6) mottles, moist, and common fine distinct dark reddish brown (5YR 2/2) mottles, moist; massive; hard, firm, slightly sticky and slightly plastic; common fine and medium segregations of lime; strong effervescence; mildly alkaline.

Depth to free carbonates ranges from 30 to 44 inches. The A horizon is dark gray or very dark gray in a hue of 10YR or 2.5Y. It is 12 to 20 inches thick. The B2t horizon ranges from dark gray to light olive gray in a hue of 2.5Y or 5Y. It is 38 to 48 percent clay and ranges from 16 to 22 inches in thickness. Mottles in the lower part of the B horizon and in the C horizon range from few to many. Segregations of lime are few or common in the C horizon.

Chancellor soils are mapped with or are near Wakonda, Wentworth, and Worthing soils and are similar to Benclare soils. Moist colors of very dark gray or darker are nearer the surface in Chancellor soils than in Benclare soils. Chancellor soils are less calcareous and have more clay than Wakonda soils. They have a more clayey B horizon than Wentworth soils and are better drained than Worthing soils.

Crofton Series

The Crofton series consists of deep, well drained, gently sloping to very steep, silty soils on uplands. These soils formed in loess. The native vegetation consisted mainly of mid and tall grasses, but deciduous trees and shrubs grew in some areas.

In a representative profile the surface layer is calcareous, pale brown silt loam about 5 inches thick. The layer below that is calcareous, pale brown silt loam about 4 inches thick. The underlying material is calcareous, light yellowish brown silt loam.

Crofton soils have low fertility and a low organic-matter content. Permeability is moderate, and the available water capacity is high.

Many areas are used for crops or have been seeded to tame grasses and legumes. Most of the steeper areas remain in native vegetation and are used for pasture and hay.

Representative profile of Crofton silt loam, in an area of Crofton-Nora silt loams, 6 to 12 percent slopes, eroded, 204 feet north and 500 feet west of the southeast corner of sec. 27, T. 94 N., R. 49 W.

Ap—0 to 5 inches; pale brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; weak fine granular structure; soft, friable; few fine concretions of lime; strong effervescence; mildly alkaline; abrupt smooth boundary.

AC—5 to 9 inches; pale brown (10YR 6/3) silt loam, dark brown (10YR 4/3) moist; weak coarse subangular blocky structure parting to weak fine subangular blocky; slightly hard, friable; few fine and medium concretions of lime; strong effervescence; moderately alkaline; clear wavy boundary.

C1—9 to 23 inches; light yellowish brown (2.5Y 6/3) silt loam, yellowish brown (10YR 5/4) moist; few fine distinct strong brown (7.5YR 5/6) and gray (5Y 5/1) mottles, moist; weak coarse subangular blocky structure; slightly hard, very friable; common fine concretions and segregations of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C2—23 to 60 inches; light yellowish brown (2.5Y 6/3) silt loam, yellowish brown (10YR 5/4) moist; common medium distinct strong brown (7.5YR 5/6) and gray (5Y 5/1) mottles, moist. and common fine distinct very dark brown (10YR 2/2) mottles, moist; massive; slightly hard, very friable; few fine concretions of lime; strong effervescence; moderately alkaline.

Lime is common at the surface, but in places it is leached to a depth of 4 to 8 inches. In cultivated areas few to many, fine and medium concretions of lime are on the surface. The A horizon ranges from grayish brown to pale brown. The C horizon ranges from brown to pale yellow.

Crofton soils are mapped with Nora soils and are near Moody and Shindler soils. Crofton soils are shallower to lime than Moody and Nora soils and are more silty than Shindler soils.

CbE2—Crofton silt loam, 12 to 17 percent slopes, eroded. This is a strongly sloping soil on the sides of large drainageways on uplands. Most of the original surface layer has been removed by erosion or has been mixed with the underlying material by tillage. This soil has a profile similar to the one described as representative of the series, but the surface layer is grayish brown in a few areas that remain in native grasses or that are not so eroded as most other areas.

Included with this soil in mapping, and making up about 20 percent of any given area, are small areas of Alcester, Moody, and Nora soils. Alcester soils are on foot slopes and along drainageways. Moody and Nora soils are on the mid and lower parts of the landscape immediately above Alcester soils. Small outcrops of glacial till and small sandy spots are in some areas and are shown on the soil map by a special symbol.

Runoff is rapid, and the hazard of erosion is very severe. Controlling erosion and improving fertility are the main concerns of management.

Most areas are cultivated or have been seeded to tame grasses and legumes. A few areas remain in native grasses and are used for pasture. Because of the very severe erosion hazard, this soil is better suited to pasture or hay than to other uses. Capability unit VIe-3, pasture group G, windbreak group 10.

CbF—Crofton silt loam, 17 to 30 percent slopes. This is a moderately steep to steep soil on the sides of valleys of the larger streams. It has a profile similar to the one described as representative of the series, but in many places the surface layer is grayish brown and noncalcareous (fig. 3).

Included with this soil in mapping are small areas of Alcester, Moody, and Nora soils. Alcester soils are on foot slopes and along drainageways. Moody and Nora soils are on the mid and lower parts of the landscape below Crofton soils. Small outcrops of glacial till and limestone are in some areas and are shown on the soil map by a special symbol.

Runoff is rapid, and the hazard of erosion is very severe. Gullies form easily in small drainageways and sags. Controlling erosion is the main concern of management.

Almost all areas remain in native grasses and are used for pasture or hay. A few areas that had been cropped are now seeded to tame grasses and legumes. This soil is too erodible for cultivation. Capability unit VIe-3, pasture group G, windbreak group 10.

CnB—Crofton-Nora silt loams, 2 to 6 percent slopes. These are gently sloping soils in long, narrow areas on upland ridgetops. They have smooth, well rounded slopes. Crofton and Nora soils occur in almost equal proportions in all areas, but the Crofton soil is on the top and upper side of convex ridges and knolls, and the Nora soil is on the side of ridges and knolls and on some of the flat ridgetops. The Nora soil has a profile similar to the one described as representative of the series, but the surface layer is silt loam.

Included with these soils in mapping are small areas of Moody soils on the lower part of the landscape.

Runoff is medium, and the hazard of erosion is moderate. The Nora soil has medium fertility, and the Crofton soil has low organic-matter content and low fertility. Controlling erosion and improving fertility are the main concerns of management.

Almost all areas are cultivated. Corn, oats, and alfalfa are the main crops. Crofton soil in capability unit IIIe-6, pasture group G, windbreak group 8; Nora soil in capability unit IIe-3, pasture group F, windbreak group 3.

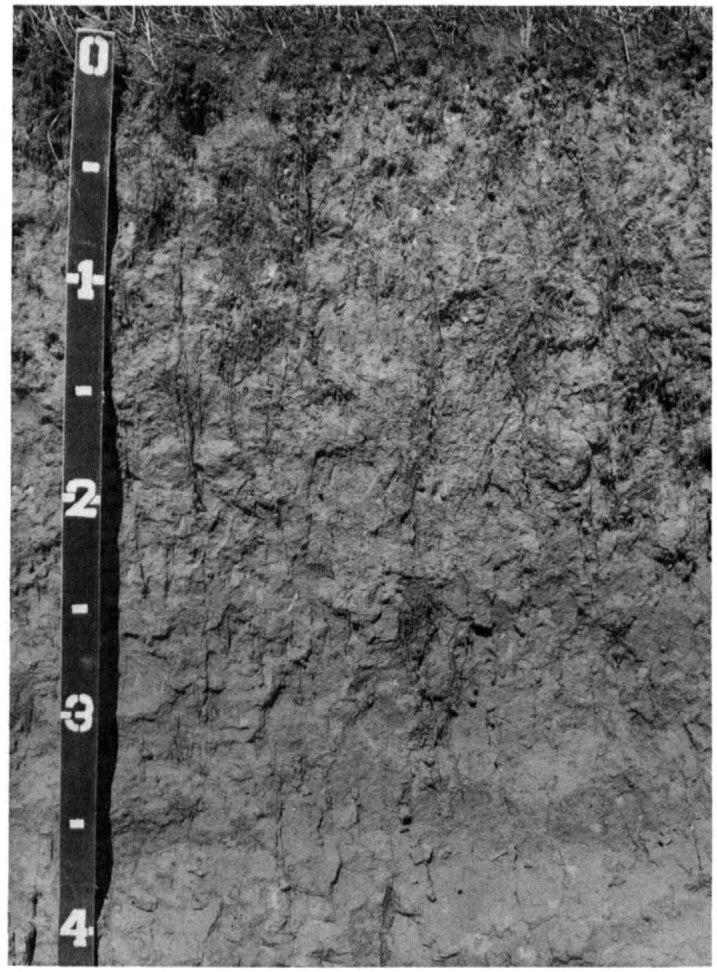

Figure 3.—**Profile of Crofton silt loam, 17 to 30 percent slopes.**

CnD2—Crofton-Nora silt loams, 6 to 12 percent slopes, eroded. This complex is about 55 percent Crofton soil, 25 percent Nora soil, and 20 percent other soils. The areas are irregularly shaped and range to several hundred acres in size. The soils have long, smooth slopes. The Crofton soil is in the highest areas where slopes are more convex. The Nora soil is on the mid and lower parts of the landscape. The Crofton soil has the profile described as representative of the series. The Nora soil has a surface layer of silt loam and is shallower to lime than the Nora soil described as representative of the series. These soils are moderately to severely eroded. Much of the original surface layer has been removed by erosion, and the rest has been mixed with the underlying material by plowing (fig. 4). Gullies have formed in some areas.

Included with these soils in mapping are small areas of Alcester and Moody soils. Alcester soils are on foot slopes and along drainageways. Moody soils are on the lower parts of the landscape above the Alcester soils.

Runoff is rapid, and the hazard of erosion is severe. These soils have low organic-matter content and low fertility. Controlling erosion and improving fertility are the main concerns of management.

Most areas are used for corn, oats, alfalfa, and tame grasses. Capability unit IVe-2; Crofton soil in pasture

Figure 4.—**Tillage has mixed the surface layer and the underlying layers in this area of Crofton-Nora silt loams, 6 to 12 percent slopes, eroded.**

group G and windbreak group 8; Nora soil in pasture group F and windbreak group 3.

Davis Series

The Davis series consists of deep, moderately well drained, nearly level, loamy soils on high stream bottoms. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is dark gray loam about 7 inches thick. The subsoil is loam about 45 inches thick. It is dark gray in the upper part, dark grayish brown in the middle, and dark brown in the lower part. The underlying material is calcareous, brown loam.

Davis soils have high fertility and high organic-matter content. Permeability is moderate, and the available water capacity is high. Most areas receive runoff from adjacent uplands.

Most areas are used for crops. A few areas are used for pasture and hay.

Representative profile of Davis loam, in cultivation, 162 feet south and 1,450 feet west of the northeast corner of sec. 15, T. 95 N., R. 48 W.

Ap—0 to 7 inches; dark gray (10YR 4/1) loam, black (10YR 2/1) moist; weak fine granular structure; slightly hard, friable, slightly sticky; slightly acid; abrupt smooth boundary.

B1—7 to 14 inches; dark gray (10YR 4/1) loam, black (10YR 2/1) moist; weak coarse prismatic structure parting to weak medium subangular blocky; slightly hard, friable, slightly sticky; slightly acid; gradual wavy boundary.

B21—14 to 20 inches; dark gray (10YR 4/1) loam, very dark brown (10YR 2/2) moist; weak coarse prismatic structure parting to weak coarse and medium subangular blocky; slightly hard, friable, slightly sticky; neutral; gradual wavy boundary.

B22—20 to 32 inches; dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak coarse prismatic structure parting to weak coarse and medium subangular blocky; slightly hard, friable, slightly sticky; neutral; gradual wavy boundary.

B23—32 to 40 inches; dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; weak coarse prismatic structure parting to moderate medium and fine subangular blocky; hard, friable, slightly sticky; neutral; gradual wavy boundary.

B3—40 to 52 inches; dark brown (10YR 4/3) loam, dark brown (10YR 3/3) moist; weak coarse prismatic structure parting to weak coarse subangular blocky; hard, friable, slightly sticky and slightly plastic; neutral; clear wavy boundary.

Cca—52 to 60 inches; brown (10YR 5/3) loam, dark brown (10YR 4/3) moist; common fine distinct strong brown (7.5YR 5/6) mottles, moist, and few medium faint dark gray mottles, moist; massive; hard, friable, slightly sticky and slightly plastic; common fine segregations of lime; strong effervescence; mildly alkaline.

Depth to lime ranges from 36 to 60 inches. The A horizon is loam

or silt loam 7 to 18 inches thick. Some pedons lack a B1 horizon. The B2 horizon is loam or silt loam. Some pedons lack a B3 horizon. The C horizon ranges from fine sandy loam to clay loam, and in places it is stratified with thin layers of fine sand.

Davis soils are near Benclare, Dempster, Enet, Graceville, Kennebec, and Salix soils and are similar to Alcester soils. Davis soils have more sand and are less silty than Alcester, Graceville, Kennebec, and Salix soils. They are less clayey than Benclare soils. Davis soils are not underlain by gravelly sand as are Dempster and Enet soils.

Da—Davis loam. This is a nearly level soil on high bottom lands along the Big Sioux River. Slopes are 0 to 2 percent. The areas are long and narrow and range to 120 acres in size. This soil has a profile similar to the one described as representative of the series, but in a few places it has sandy underlying material and in other places it is underlain by silty clay loam and is shallower to lime.

Included with this soil in mapping are small areas of Kennebec soils along drainageways that head in adjacent uplands.

Runoff is slow, and the hazard of erosion is slight. Flooding occurs mainly in spring before crops are planted. This soil has few or no limitations for crops. Maintaining fertility is the main concern of management.

Most areas are cultivated. Corn, soybeans, oats, and alfalfa are the main crops. This soil is well suited to irrigation, and in most places adequate water for irrigation can be obtained from shallow wells. Capability unit I-1, pasture group K, windbreak group 1.

Dempster Series

The Dempster series consists of well drained, nearly level to gently sloping, silty soils that are moderately deep to gravelly sand. These soils are on stream terraces. They formed in alluvium underlain by gravelly sand. The native vegetation consisted mainly of mid grasses.

In a representative profile the surface layer is dark grayish brown silty clay loam about 9 inches thick. The subsoil is about 25 inches thick. It is dark grayish brown silty clay loam in the upper part, brown silty clay loam in the middle, and yellowish brown silt loam in the lower part. The underlying material is calcareous, gravelly sand (fig. 5). It is yellowish brown to a depth of 38 inches and light yellowish brown below.

Dempster soils have moderate organic-matter content and medium fertility. Permeability is moderate in the subsoil and rapid in the underlying gravelly sand. The available water capacity is moderate.

Most areas are cultivated. These soils are well suited to irrigation. A few areas remain in native grass and are used for pasture and hay.

Representative profile of Dempster silty clay loam, in cultivation, 81 feet west and 560 feet north of the southeast corner of sec. 24, T. 93 N., R. 49 W.

Ap—0 to 9 inches; dark grayish brown (10YR 4/2) silty clay loam, black (10YR 2/1) moist; weak medium subangular blocky structure parting to weak fine granular; hard, friable, slightly sticky; slightly acid; abrupt smooth boundary.

B21—9 to 17 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; weak coarse prismatic structure parting to weak coarse and medium subangular blocky; slightly hard, friable, slightly sticky; slightly acid; clear wavy boundary.

B22—17 to 28 inches; brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; weak medium prismatic structure parting to moderate medium subangular blocky; slightly hard, friable, slightly sticky; medium acid; clear wavy boundary.

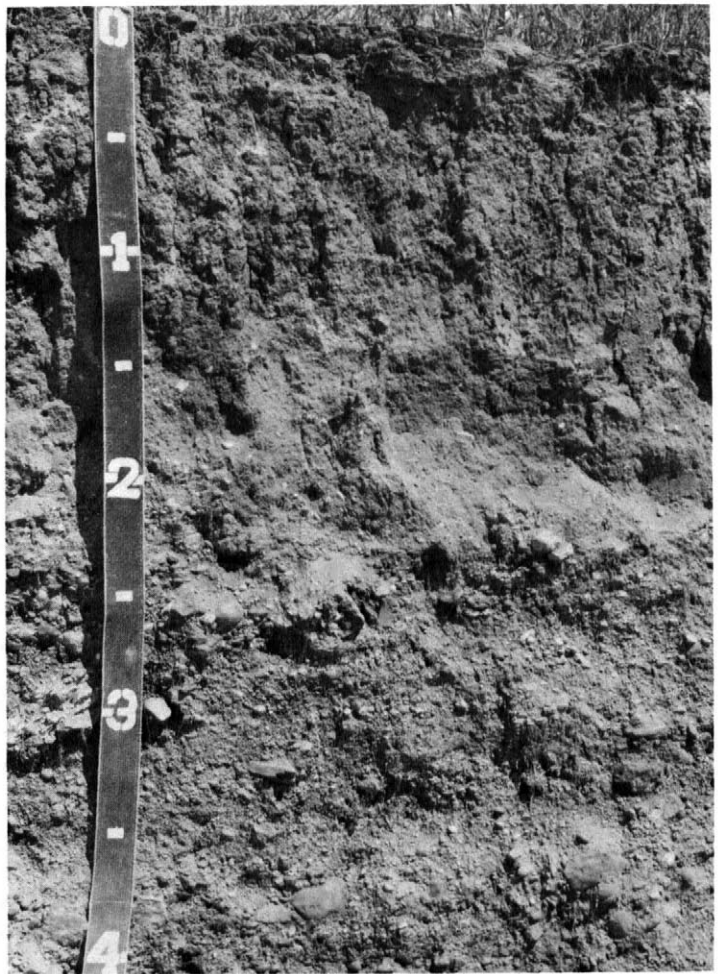

Figure 5.—**Gravelly sand is at a depth of about 30 inches in this profile of Dempster silty clay loam.**

B3—28 to 34 inches; yellowish brown (10YR 5/4) silt loam, dark brown (10YR 4/3) moist; weak coarse prismatic structure parting to weak coarse and medium subangular blocky; slightly hard, friable; medium acid; clear wavy boundary.

IIC1—34 to 38 inches; yellowish brown (10YR 5/4) gravelly sand, dark yellowish brown (10YR 4/4) moist; single grained; loose; medium acid; gradual wavy boundary.

IIC2—38 to 60 inches; light yellowish brown (10YR 6/4) gravelly sand, yellowish brown (10YR 5/4) moist; single grained; loose; weak effervescence; neutral.

Depth to gravelly sand and to lime ranges from 20 to 40 inches. The A horizon is very dark gray to dark grayish brown silty clay loam or silt loam 6 to 12 inches thick. The B2 horizon ranges from dark grayish brown to light olive brown silty clay loam or silt loam in a hue of 10YR or 2.5Y. Some pedons lack a B3 horizon, but where present it is silt loam, loam, or silty clay loam. In some pedons the entire IIC horizon is calcareous.

Dempster soils are near Enet and Graceville soils. They have a more silty B horizon than Enet soils and are shallower to gravelly sand than Graceville soils.

De—Dempster silty clay loam. This is a nearly level soil on stream terraces in irregularly shaped areas that range to 200 acres in size. Slopes are 0 to 2 percent. In most areas this soil has the profile described as representative of the series, but in some areas along Brule Creek the surface layer is loam.

Included with this soil in mapping are small areas of Enet

and Graceville soils. Enet soils are on slightly raised humps or low ridges, and Graceville soils are in swales and low areas.

Runoff is slow, and there is little or no hazard of erosion. This Dempster soil is somewhat droughty because of the underlying gravelly sand. Conserving moisture is the main concern of management.

Most areas are cultivated. Corn, oats, soybeans, and alfalfa are the main crops. If irrigated (fig. 6), this soil is well suited to corn, soybeans, and alfalfa. It is better suited to spring-sown small grain and tame grasses than to late-planted crops in nonirrigated areas. Capability unit IIs-3, pasture group D, windbreak group 6.

Egan Series

The Egan series consists of deep, well drained, gently sloping to sloping, silty soils on uplands. These soils formed in silty glacial drift overlying loamy glacial till or drift. The native vegetation consisted mainly of tall and mid grasses.

In a representative profile the surface layer is dark grayish brown silty clay loam about 8 inches thick. The subsoil is yellowish brown silty clay loam about 22 inches thick. The lower part of the subsoil is calcareous. The underlying material is calcareous, light yellowish brown clay loam.

Egan soils have high fertility and high organic-matter content. Permeability is moderate in the subsoil and moderately slow in the underlying material. The available water capacity is high.

Most areas are used for crops. A few areas are used for pasture.

Representative profile of Egan silty clay loam, in an area of Egan-Shindler complex, 2 to 6 percent slopes, in cultivation, 114 feet west and 1,760 feet south of the northeast corner of sec. 13, T. 92 N., R. 50 W.

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; weak medium subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; slightly acid; abrupt smooth boundary.

B21—8 to 13 inches; yellowish brown (10YR 5/4) silty clay loam, dark brown (10YR 3/3) moist; weak medium prismatic structure parting to weak medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; few worm channel fillings, very dark brown (10YR 2/2) moist; slightly acid; gradual wavy boundary.

B22—13 to 25 inches; yellowish brown (10YR 5/4) silty clay loam, dark brown (10YR 4/3) moist; weak coarse and medium prismatic structure parting to weak medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; neutral; clear wavy boundary.

B3ca—25 to 30 inches; yellowish brown (10YR 5/4) silty clay loam, dark brown (10YR 4/3) moist; common fine distinct strong brown (7.5YR 5/6) mottles, moist; weak coarse and medium subangular blocky structure; slightly

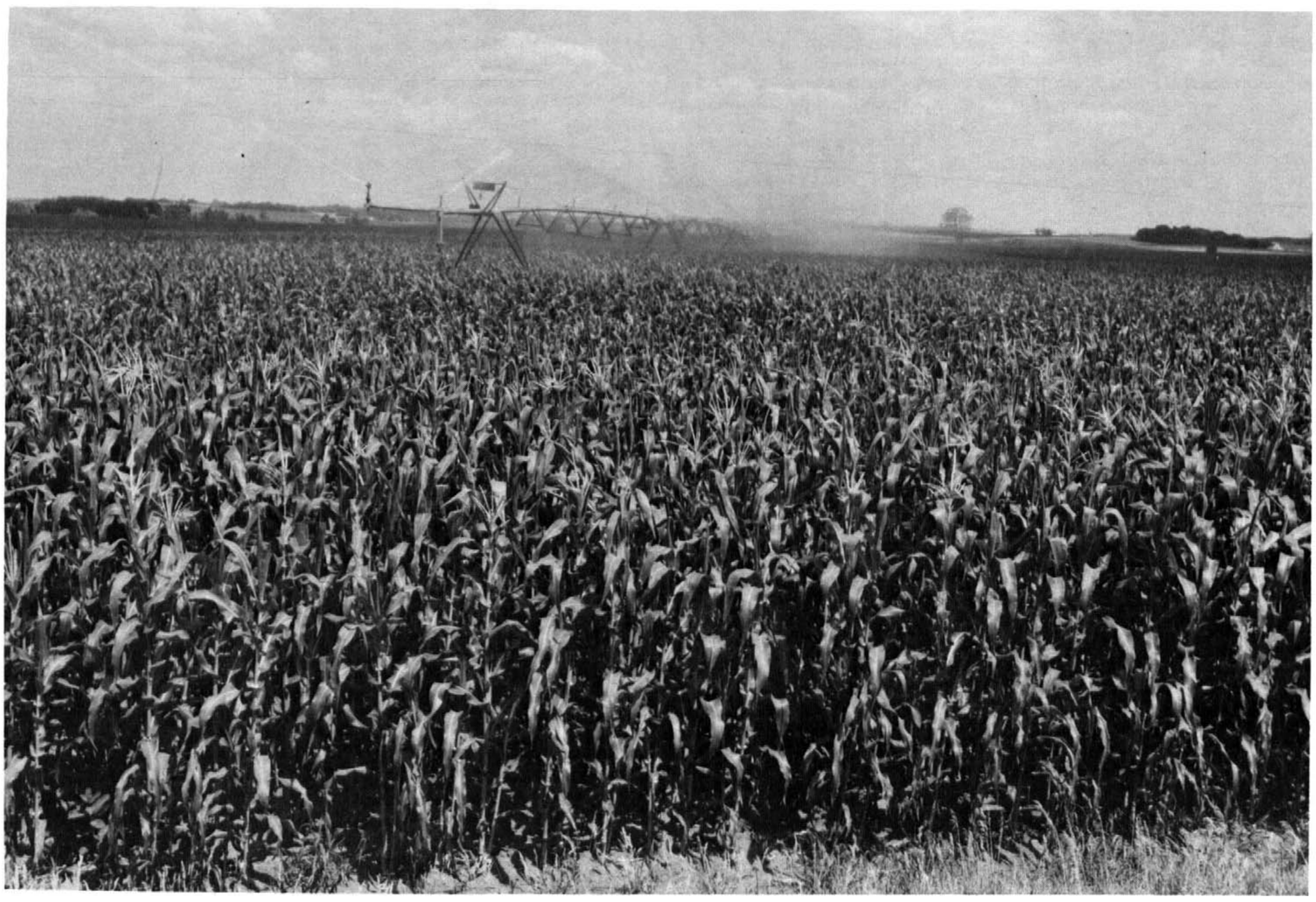

***Figure 6.*—Irrigation is beneficial to common Dempster silty clay loam.**

hard, friable, slightly sticky; common medium concretions and segregations of lime; strong effervescence; mildly alkaline; gradual wavy boundary.

IICca—30 to 60 inches; light yellowish brown (2.5Y 6/3) clay loam, light olive brown (2.5Y 5/4) moist; common fine distinct strong brown (7.5YR 5/6) mottles, moist, and few medium faint dark gray mottles, moist; weak, coarse and medium subangular blocky structure; hard, firm, slightly sticky and slightly plastic; many medium concretions and segregations of lime; strong effervescence; mildly alkaline.

The silty material over loamy glacial till or drift ranges from 20 to 40 inches in thickness. Depth to lime ranges from 15 to 30 inches but commonly is 22 to 26 inches. The A horizon ranges from very dark gray to dark grayish brown and is 5 to 10 inches thick. The B2 horizon ranges from dark grayish brown to yellowish brown in a hue of 10YR or 2.5Y. It is 11 to 20 inches thick. Some pedons lack a B3ca horizon. The IIC horizon is clay loam or loam.

Egan soils are mapped with Shindler soils and are near Chancellor, Wentworth, and Worthing soils. Egan soils are better drained than Chancellor and Worthing soils, and more silty and deeper to lime than Shindler soils. Unlike Wentworth soils, Egan soils have loamy material within a depth of 40 inches.

EaB—Egan-Shindler complex, 2 to 6 percent slopes. This complex is about 55 percent Egan soil, 35 percent Shindler soil, and 10 percent other soils. The areas range from 20 to 150 acres in size. Some are long and narrow and are on the sides and around the heads of small drainageways. Other areas are irregularly shaped, and the landscape is broken by small depressions and narrow swales. Slopes are gently undulating in the latter areas. The Egan soil is on the mid and lower parts of the landscape where slopes are moderately long and smooth. The Shindler soil is on the higher parts of the landscape where slopes are short and convex. The Egan soil has the profile described as representative of the series. The Shindler soil has a surface layer of clay loam that is moderately eroded in places. The surface layer is grayish brown because it has been mixed with the subsoil by plowing.

Included with these soils in mapping are small areas of Chancellor, Wentworth, and Worthing soils. Chancellor soils are in swales, and Wentworth soils are intermingled with Egan soils. Worthing soils in small depressions commonly are shown on the soil map by a wet spot symbol. Small gravelly and sandy spots are in some areas and are shown on the soil map by a special symbol.

Runoff is medium. The erosion hazard is moderate on the Egan soil and severe on the Shindler soil. Controlling erosion is the main concern of management.

Most areas are used for crops. These soils are well suited to all crops commonly grown in the county. A few areas are used for pasture. Windbreak group 3; Egan soil in capability unit IIe–3 and pasture group F; Shindler soil in capability unit IIIe–6 and pasture group G.

EaC—Egan-Shindler complex, 6 to 9 percent slopes. This complex is about 50 percent Egan soil, 40 percent Shindler soil, and 10 percent other soils. The areas are mostly long and narrow and are on the sides of drainageways. Egan soils are on the mid and lower parts of the landscape where slopes are smooth and uniform. Shindler soils are on the higher parts of the landscape where slopes are short and convex. The Egan soil has a surface layer of silty clay loam, but the lower part of the subsoil is clay loam. The Shindler soil has a surface layer of clay loam that is moderately eroded in places. The surface layer is grayish brown because it has been mixed with the subsoil by plowing.

Included with these soils in mapping are small areas of Alcester and Wentworth soils. Alcester soils are along drainageways on the lower parts of the landscape. Wentworth soils are intermingled with Egan soils. Small gravelly spots are in some higher areas and are shown on the soil map by a special symbol.

Runoff is medium, and the hazard of erosion is severe. Controlling erosion is the main concern of management.

Most areas are cultivated. A few areas remain in native grass and are used for pasture. These soils are suited to all crops commonly grown in the county, but they are better suited to close-sown crops than to row crops because of the erosion hazard. Windbreak group 3; Egan soil in capability unit IIIe–2 and pasture group F; Shindler soil in capability unit IVe–2 and pasture group G.

Enet Series

The Enet series consists of deep, well drained, nearly level to gently sloping, loamy soils that are moderately deep to gravelly loamy sand. These soils are on stream terraces. They formed in loamy alluvium overlying outwash sand and gravel. The native vegetation consisted mainly of tall and mid grasses.

In a representative profile the surface layer is dark gray loam about 6 inches thick. The subsoil is about 18 inches thick. It is dark grayish brown loam in the upper 14 inches and dark grayish brown sandy loam in the lower 4 inches. The underlying material is brown gravelly sandy loam to a depth of 33 inches and brown gravelly loamy sand below.

Enet soils have high organic-matter content and medium fertility. Permeability is moderate in the subsoil and rapid in the sandy underlying material. The available water capacity is low or moderate.

Most areas are used for crops. Unless irrigated, these soils are better suited to tame grasses and small grain than to row crops.

Representative profile of Enet loam, 0 to 2 percent slopes, in cultivation, 2,300 feet west and 905 feet south of the northeast corner of sec. 28, T. 95 N., R. 48 W.

Ap—0 to 6 inches; dark gray (10YR 4/1) loam, black (10YR 2/1) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky; slightly acid; abrupt smooth boundary.

B21—6 to 14 inches; dark grayish brown (10YR 4/2) loam, black (10YR 2/1) moist crushing to very dark brown (10YR 2/2) moist; weak medium prismatic structure parting to weak medium subangular blocky; slightly hard, friable, slightly sticky; few pebbles; neutral; gradual wavy boundary.

B22—14 to 20 inches; dark grayish brown (10YR 4/2) loam, very dark brown (10YR 2/2) moist, crushing to very dark grayish brown (10YR 3/2) moist; weak medium prismatic structure parting to weak medium subangular blocky; slightly hard, very friable; few pebbles; neutral; clear wavy boundary.

B3—20 to 24 inches; dark grayish brown (10YR 4/2) sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; slightly hard, very friable; neutral; clear wavy boundary.

C1—24 to 33 inches; brown (10YR 5/3) gravelly sandy loam, dark brown (10YR 4/3) moist; single grained; loose; neutral; gradual wavy boundary.

IIC2—33 to 60 inches; brown (10YR 5/3) gravelly loamy sand, dark brown (10YR 4/3) moist; single grained; loose; few crusts of lime on pebbles; mildly alkaline.

Depth to gravelly loamy sand or gravelly sand ranges from 28 to 40 inches. The A horizon ranges from very dark gray to dark grayish brown. It is 6 to 9 inches thick. The B2 horizon is very dark gray to grayish brown loam or light clay loam. The B3 horizon is loam or sandy loam. Most pedons have a C1 horizon of gravelly sandy loam or sandy loam.

Enet soils in Union County have thicker transitional horizons of sandy loam or gravelly sandy loam than is defined as the range of the series. This difference does not alter the usefulness or behavior of the soils.

Enet soils have more sand in the B horizon than the nearby Dempster and Graceville soils.

EmA—Enet loam, 0 to 2 percent slopes. This nearly level soil is on stream terraces. The areas are irregularly shaped and are mostly less than 100 acres in size. In most areas this soil has the profile described as representative of the series, but in places the underlying gravelly loamy sand or gravelly sand is at a depth of 36 to 60 inches.

Included with this soil in mapping is an area of a somewhat poorly drained soil that has a seasonal water table at a depth of 3 to 5 feet.

Runoff is slow. This soil takes in water readily, but it is somewhat droughty because of the underlying gravelly loamy sand. It also is subject to soil blowing in dry years. Conserving moisture is the main concern of management.

Most areas are cultivated. If irrigated, this soil is well suited to all crops grown in the county. In nonirrigated areas this soil is better suited to small grain and tame grasses than to late-maturing crops such as corn and soybeans. Capability unit IIs-3, pasture group D, windbreak group 6.

EnB—Enet and Dempster soils, 2 to 6 percent slopes. These soils are gently sloping and are on terrace fronts along major streams. The areas are long and narrow and range from 5 to 35 acres in size. Some areas are mostly Enet soil, some are mostly Dempster soil, and some contain both soils in varying proportions. The surface layer ranges from sandy loam to silty clay loam but it is commonly loam in the Enet soil and silty clay loam in the Dempster soil.

Included with these soils in mapping are small areas of a soil that is deeper to gravelly sand than the Dempster soil. Also included is an area of a soil that has a more sandy subsoil than the Enet soil.

Runoff is medium. These soils are somewhat droughty because of the gravelly underlying material. They are moderately susceptible to erosion and soil blowing. Conserving moisture and controlling erosion and soil blowing are the main concerns of management.

Most areas are cultivated. If irrigated, these soils are suited to all crops commonly grown in the county. In nonirrigated areas they are better suited to small grain and tame grasses than to late-maturing crops such as corn and soybeans. Capability unit IIIs-2, pasture group D, windbreak group 6.

Fluvaquents

Fluvaquents consist of mixed, somewhat poorly drained to very poorly drained, alluvial soils on bottom lands. These soils have a surface layer of loamy sand to clay and are underlain by layers of sediments that have contrasting textures. The areas are subject to flooding and commonly have a seasonal water table at a depth of 3 feet or less. The native vegetation consisted mainly of trees, tall grasses, and sedges, but rushes and cattails grew in some wetter areas.

Fa—Fluvaquents. These are nearly level, alluvial soils on low bottoms in the oxbows of the Big Sioux River. Slopes are 0 to 3 percent. The surface layer commonly is loamy sand to loam and is underlain by stratified sandy to loamy alluvium. In some low areas or depressions the soil is clay.

Runoff is slow and accumulates in some partly filled old channels or depressions. Overcoming wetness that results from flooding and from a seasonal high water table is the main concern of management. Some sandy areas are droughty and are subject to soil blowing if the vegetation is removed.

Most areas remain in native vegetation and are used for pasture, hay, and wildlife habitat. A few areas have been cleared of trees and are used for crops, but the choice of crops is limited by wetness during the early part of the growing season. Capability unit IVw-2, pasture group A, windbreak group 2.

Fb—Fluvaquents, wet. These are level soils on bottom lands in partly filled old channels and meander scars. Some areas consist mainly of low-lying bars along the main channel of the Missouri River. Slopes are 0 to 1 percent.The surface layer is mostly loamy sand to loam, but in a few areas it is clay. The underlying alluvium ranges from sand to clay and commonly is stratified.

Runoff is very slow to ponded. All areas are subject to flooding, and some are under water much of the time (fig. 7). The water table is at or near the surface. Wetness limits the use of these soils to pasture, hay, and wildlife habitat.

Most areas remain in native vegetation. Areas that are mainly in willows, cattails, rushes, and other aquatic plants are best suited to wildlife habitat. Areas that are in tall grasses and other vegetation palatable to livestock can be grazed late in summer and in fall or can be cut for wild hay. Capability unit Vw-2 if grazable, VIIIw-1 if nongrazable; not placed in pasture group; windbreak group 10.

Forney Series

The Forney series consists of deep, poorly drained, level, clayey soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is silty clay about 11 inches thick. It is gray in the upper part and dark gray in the lower part. The subsoil is dark gray and gray silty clay about 10 inches thick. Below that is very dark gray and dark gray silty clay about 13 inches thick. Below that is gray silty clay.

Forney soils have high fertility and high organic-matter content. Permeability is very slow, and the available water capacity is low or moderate. Forney soils have a seasonal high water table at a depth of 1 to 3 feet. Some areas are subject to flooding.

Most areas are used for crops. A few areas are used for pasture or hay.

Representative profile of Forney silty clay, in cultivation, 130 feet south and 1,500 feet east of the northwest corner of sec. 1, T. 90 N., R. 49 W.

Ap—0 to 7 inches; gray (10YR 5/1) silty clay, very dark gray (10YR 3/1) moist; few medium distinct olive brown (2.5Y 4/4) mottles, moist; moderate fine subangular blocky structure; very hard, firm, sticky and plastic; slightly acid; abrupt smooth boundary.

A3—7 to 11 inches; dark gray (10YR 4/1) silty clay, very dark gray (2.5Y 3/1) moist; common fine distinct olive brown (2.5Y 4/3) mottles, moist; moderate fine subangular blocky structure; very hard, firm, sticky and plastic; slightly acid; clear smooth boundary.

B2g—11 to 21 inches; dark gray (5Y 4/1) and gray (5Y 5/1) silty clay, very dark gray (5Y 3/1) and dark gray (5Y 4/1) moist; many fine distinct olive brown (2.5Y 4/3) and yellowish brown (10YR 5/6) mottles, moist, and common medium faint olive gray mottles, moist; weak coarse subangular blocky structure parting to moderate fine subangular blocky; extremely hard, very firm, sticky and plastic; shiny coats on faces of peds; neutral; clear smooth boundary.

Figure 7.—**Floodwater has accumulated in the old channel within this area of Fluvaquents, wet. Aquatic plants grow where the water table is at the surface.**

IIA1b—21 to 29 inches; very dark gray (2.5Y 3/1) silty clay, black (N 2/0) moist; few fine faint olive brown mottles, moist; moderate fine subangular blocky structure; very hard, firm, sticky and plastic; neutral; clear smooth boundary.

IIA3b—29 to 34 inches; dark gray (5Y 4/1) silty clay, black (5Y 2/1) and very dark gray (5Y 3/1) moist; few fine distinct dark yellowish brown (10YR 4/4) mottles, moist, and common fine faint olive gray mottles, moist; moderate medium and fine subangular blocky structure; extremely hard, very firm, sticky and plastic; neutral; gradual smooth boundary.

IIB2gb—34 to 44 inches; gray (5Y 5/1) silty clay, dark gray (5Y 4/1) and very dark gray (5Y 3/1) moist; many fine distinct strong brown (7.5YR 5/6) and olive brown (2.5Y 4/4) mottles, moist, and common fine distinct black (5Y 2/1) mottles, moist; moderate medium and fine subangular blocky structure; extremely hard, very firm, sticky and plastic; shiny coats on faces of peds; neutral; gradual smooth boundary.

IIB3gb—44 to 60 inches; gray (5Y 6/1) silty clay, dark gray (5Y 4/1) moist; many fine and medium distinct olive brown (2.5Y 4/4) and yellowish brown (10YR 5/6) mottles, moist, and few coarse faint gray mottles, moist; weak medium subangular blocky structure; extremely hard, very firm, sticky and plastic; shiny coats on faces of peds; few fine concretions of lime; neutral.

The solum is 15 to 24 inches thick and is underlain by a buried soil. Lime commonly is leached to a depth of 36 inches or more, but in places it is at a depth of 20 to 36 inches. The A horizon commonly is silty clay, but in places it is silt loam or silty clay loam. It is 5 to 11 inches thick. Some pedons lack an A3 horizon. Texture below the A horizon is silty clay or clay. The B2g horizon ranges from dark gray to grayish brown in a hue of 5Y or 2.5Y, and it has few to many mottles. It is 6 to 10 inches thick. The IIAb horizon is 10 to 16 inches thick. The IIBg horizon is gray or grayish brown in a hue of 5Y or 2.5Y, and it has few to many mottles.

Forney soils are near Albaton, Benclare, Blencoe, Lakeport, and Luton soils. Unlike Albaton soils, Forney soils are noncalcareous to a depth of 20 inches or more. They are more poorly drained than Benclare, Blencoe, and Lakeport soils. Forney soils have thinner A and B horizons than Luton soils.

Fc—Forney silty clay. This is a level, clayey soil on high stream bottoms. Slopes are 0 to 1 percent. The areas commonly are large and range to several hundred acres in size. In most areas this soil has the profile described as representative of the series, but in places the depth to lime is as shallow as 20 inches. In a few places a thin layer of silt loam is below the subsoil.

Runoff is slow. Wetness from flooding or from a seasonal high water table commonly delays spring planting and tillage. The clayey surface layer dries slowly, and it compacts and loses its tilth if farmed when wet. Overcoming wetness is the main concern of management.

Most areas are used for crops. This soil is better suited to corn, soybeans, and winter wheat than to spring-sown small

grain. Capability unit IIIw-2, pasture group A, windbreak group 2.

Fe—Forney soils, overwash. These are level soils on high stream bottoms in irregularly shaped areas that range from 20 to 200 acres in size. Slopes are 0 to 1 percent. These soils have 5 to 15 inches of recent overwash on the surface. The overwash consists of calcareous, grayish brown silt loam, very fine sandy loam, or silty clay loam. Some low spots have no overwash and have a surface layer of silty clay.

Included with these soils in mapping are small areas of Modale soils on very narrow, low humps.

These Forney soils have a seasonal high water table. Areas adjacent to the Big Sioux River are subject to flooding. Runoff is slow, but the overwash layer dries quickly and is easy to work. Fertility is low, however, because of the overwash layer. Overcoming wetness and improving fertility are the main concerns of management.

Most areas are used for crops. Corn, oats, soybeans, and alfalfa are the main crops. Capability unit IIw-1, pasture group A, windbreak group 2.

Grable Series

The Grable series consists of deep, somewhat excessively drained, nearly level, silty soils that are underlain by fine sand at a moderate depth. These soils are on bottom lands. They formed in alluvium. The native vegetation consisted mainly of tall and mid grasses and a few deciduous trees.

In a representative profile the surface layer is calcareous, grayish brown silt loam about 7 inches thick. The underlying material is calcareous, light gray silt loam to a depth of 15 inches and is calcareous, light brownish gray very fine sandy loam to a depth of 27 inches. Below this is calcareous, light olive brown fine sand.

Grable soils have moderately low organic-matter content and medium fertility. Permeability is moderate in the upper part and rapid in the sandy lower part. The available water capacity is moderate. These soils have a seasonal high water table at a depth of 2 to 5 feet.

Most areas are cultivated. A few areas remain in native vegetation and are used for pasture.

Representative profile of Grable silt loam, in cultivation, 205 feet west and 106 feet south of the northeast corner of sec. 6, T. 90 N., R. 49 W.

Ap—0 to 7 inches; grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable; slight effervescence; mildly alkaline; abrupt smooth boundary.

C1—7 to 15 inches; light gray (2.5Y 7/2) silt loam, grayish brown (2.5Y 5/2) moist; common fine distinct strong brown (7.5YR 5/6) mottles, moist; massive, laminations evident; soft, very friable; strong effervescence; mildly alkaline; clear wavy boundary.

C2—15 to 27 inches; light brownish gray (2.5Y 6/2) very fine sandy loam, dark grayish brown (2.5Y 4/2) moist; few fine distinct gray (5Y 5/1) and strong brown (7.5YR 5/6) mottles, moist; massive, laminations evident; soft, very friable; common fine dark stains of iron and manganese oxides; a 1/2-inch thick lens of silty clay loam at about 16 inches and a 1-inch thick lens of fine sand at about 19 inches; strong effervescence; mildly alkaline; abrupt smooth boundary.

IIC3—27 to 60 inches; light olive brown (2.5Y 5/3) fine sand, olive brown (2.5Y 4/3) moist; single grained; loose; strong effervescence; mildly alkaline.

Thickness of the loamy material over coarse alluvium ranges from 18 to 30 inches. The A horizon commonly is silt loam 6 to 10 inches thick, but it is very fine sandy loam in places. A thin overwash of silty clay loam or silty clay is on the surface in places. The IIC horizon is fine sand, loamy fine sand, sand, or loamy sand stratified, in places, with thin lenses of finer textured material.

Grable soils are near Albaton, Haynie, Onawa, Percival, and Sarpy soils. Grable soils are better drained and less clayey than Albaton, Onawa, and Percival soils. They have a more sandy C horizon than Haynie soils. They contain more silt and very fine sand to a greater depth than Sarpy soils.

Ga—Grable silt loam. This is a nearly level soil on bottom lands. Slopes are 0 to 2 percent. The areas are long and narrow and are mostly less than 30 acres in size. In most areas this soil has the profile described as representative of the series, but in places the surface layer is silty clay loam.

Included with this soil in mapping are small areas of Haynie, Onawa, and Percival soils. Haynie soils are the most common and make up as much as 30 percent of some areas. Onawa and Percival soils are in swales or low areas.

Runoff is slow. This soil is somewhat droughty because of the sandy underlying material, and it is subject to some soil blowing. Conserving moisture and controlling soil blowing are the main concerns of management.

Most areas are cropped. A few areas are irrigated. If irrigated, this soil is well suited to corn, soybeans, and alfalfa. In nonirrigated areas it is better suited to small grain than to late-maturing row crops. Capability unit IIs-3, pasture group D, windbreak group 6.

Graceville Series

The Graceville series consists of deep, moderately well drained, nearly level, silty soils on stream terraces. These soils formed in alluvium overlying outwash sand and gravel. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is silty clay loam about 16 inches thick. It is dark grayish brown in the upper part and dark gray in the lower part. The subsoil is silty clay loam about 36 inches thick. It is dark grayish brown in the upper part, grayish brown in the middle, and light yellowish brown in the lower part. The underlying material is brown gravelly sand.

Graceville soils have high fertility and high organic-matter content. Permeability is moderate, and the available water capacity is high.

Almost all areas are cropped. These soils are well suited to all crops commonly grown in the county.

Representative profile of Graceville silty clay loam, in cultivation, 820 feet south and 2,580 feet east of the northwest corner of sec. 29, T. 92 N., R. 49 W.

Ap—0 to 7 inches; dark grayish brown (10YR 4/2) silty clay loam, black (10YR 2/1) and very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable; medium acid; abrupt smooth boundary.

A12—7 to 16 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak coarse subangular blocky structure parting to weak fine granular; slightly hard, friable; common fine pores, few pebbles and visible sand grains; medium acid; gradual wavy boundary.

B1—16 to 24 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist, few tongues of black (10YR 2/1) moist; weak coarse prismatic structure parting to weak medium and fine subangular blocky; slightly hard, friable; common fine pores; few pebbles and visible sand grains; slightly acid; gradual wavy boundary.

B21—24 to 36 inches; grayish brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak coarse prismatic structure parting to moderate medium and fine subangular blocky; slightly hard, friable, slightly

sticky; common fine pores; few pebbles and visible sand grains; slightly acid; gradual wavy boundary.

B22—36 to 52 inches; light yellowish brown (2.5Y 6/3) silty clay loam, olive brown (2.5Y 4/3) moist; weak coarse prismatic structure parting to moderate medium and fine subangular blocky; slightly hard, friable, slightly sticky; neutral; abrupt smooth boundary.

IIC—52 to 60 inches; brown (10YR 5/3) gravelly sand, dark brown (10YR 4/3) moist; single grained; loose; strong effervescence; mildly alkaline.

Depth to gravelly sand ranges from 40 to 60 inches. The A horizon ranges from very dark gray to dark grayish brown and in places is silt loam. It is 12 to 22 inches thick. The B2 horizon ranges from dark grayish brown to yellowish brown. Some pedons have a thin B3 horizon. The IIC horizon ranges from fine sand to gravel, and in places it is noncalcareous.

Graceville soils are near Alcester, Benclare, Davis, Dempster, Enet, and Kennebec soils. Unlike Alcester, Benclare, Davis, and Kennebec soils, Graceville soils have a C horizon of gravelly sand. Graceville soils are deeper to gravelly sand than Dempster and Enet soils.

Gb—Graceville silty clay loam. This is a nearly level soil on stream terraces in broad areas that range to 240 acres in size. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Dempster soils on slightly raised humps.

Runoff is slow, and there is little or no risk of erosion. Some areas receive runoff from adjacent soils, and this additional moisture generally is beneficial. This soil has few or no limitations for crops.

Almost all areas are cultivated. Corn, soybeans, and alfalfa are the main crops. In places the underlying gravelly sand has been excavated for construction uses. Capability unit I-3, pasture group K, windbreak group 1.

Haynie Series

The Haynie series consists of deep, well drained and moderately well drained, level and nearly level, silty soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of mid and tall grasses and a few deciduous trees.

In a representative profile the surface layer is calcareous, light brownish gray silt loam about 8 inches thick. The underlying material is calcareous, light brownish gray silt loam and very fine sandy loam.

Haynie soils have moderately low organic-matter content and medium fertility. Permeability is moderate, and the available water capacity is high.

Most areas are cropped. Some areas are irrigated. A few areas remain in native vegetation and are used for pasture.

Representative profile of Haynie silt loam, in cultivation, 1,150 feet south and 2,150 feet west of the northeast corner of sec. 35, T. 89 N., R. 49 W. (Original 1860 survey).

Ap—0 to 8 inches; light brownish gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist; few spots of decomposed very dark brown (10YR 2/2) organic material, moist; weak fine granular structure; soft, very friable; few fine root channels; strong effervescence; mildly alkaline; abrupt smooth boundary.

C1—8 to 18 inches; light brownish gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist; few fine faint grayish brown mottles, moist; massive, laminations evident; soft, very friable; strong effervescence; mildly alkaline; clear smooth boundary.

C2—18 to 21 inches; light brownish gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist; common fine distinct strong brown (7.5YR 5/6) mottles, moist, and common medium distinct gray (5Y 5/1) mottles, moist; massive, laminations evident; slightly hard, friable; strong effervescence; mildly alkaline; clear smooth boundary.

C3—21 to 60 inches; light brownish gray (2.5Y 6/2) very fine sandy loam, dark grayish brown (2.5Y 4/2) moist; common fine distinct strong brown (7.5YR 5/6) mottles, moist, and few fine faint gray mottles, moist; massive, laminations evident; soft, very friable; thin lenses of fine sand at about 30 inches; strong effervescence; mildly alkaline.

All horizons are silt loam or very fine sandy loam, but some places have an overwash of silty clay loam or silty clay. The A horizon is light brownish gray or grayish brown in a hue of 2.5Y or 10YR. It is 6 to 10 inches thick. In places it is noncalcareous. In places the C horizon is stratified with thin lenses of clayey or sandy material.

Haynie soils in this survey commonly have an A horizon that is lighter colored than is defined as the range of the series. This difference does not alter the usefulness or behavior of the soils.

Haynie soils are near Albaton, Blyburg, Grable, and Onawa soils and are similar to McPaul soils. Haynie soils have less clay than Albaton and Onawa soils and a thinner A horizon than Blyburg soils. Haynie soils have a less sandy C horizon than Grable soils and contain more sand in the C horizon than McPaul soils.

Ha—Haynie silt loam. This is a nearly level soil on bottom lands in irregularly shaped areas that are mostly less than 100 acres in size. Slopes are 0 to 2 percent. This soil has the profile described as representative of the series, but in some narrow swales and low areas the surface layer is silty clay loam.

Included with this soil in mapping are small areas of Onawa and Grable soils. Onawa soils are in small swales and low areas, and Grable soils are on very slight rises. Also included in some areas are small sandy spots that are shown on the soil map by a special symbol.

Runoff is slow. This Haynie soil is well drained and has few limitations for crops. Maintaining fertility and organic-matter content is the main concern of management.

Most areas are cultivated. Some areas are irrigated. Corn and soybeans are the main crops, but small grain and alfalfa also are grown. Capability unit I-1, pasture group F, windbreak group 1.

Hb—Haynie silty clay loam. This is a level soil in swales on bottom lands. Slopes are 0 to 1 percent. The areas are long and narrow and are mostly less than 60 acres in size. This soil has an overwash layer of silty clay loam 5 to 15 inches thick. In places the overwash layer is silty clay. Some larger areas contain small humps or rises that have no overwash layer.

Included with this soil in mapping are small areas of Onawa soils in low areas.

This Haynie soil is moderately well drained and has a seasonal water table at a depth of 4 to 8 feet. Runoff is slow. Most areas receive runoff from nearby soils, but farming seldom is delayed by wetness. The surface layer dries slowly, however, and compacts if farmed when wet. This soil has only slight limitations for crops. Maintaining tilth and fertility is the main concern of management.

Most areas are cultivated. Corn and soybeans are the main crops, but alfalfa also is grown. Capability unit I-1, pasture group F, windbreak group 1.

James Series

The James series consists of deep, poorly drained, level soils that are high in salt content. These soils are on bottom lands. They formed in alluvium. The native vegetation consisted mainly of tall grasses, rushes, sedges, and a few deciduous trees.

In a representative profile the surface layer is calcareous,

dark gray silty clay about 30 inches thick. The underlying material is calcareous, light olive gray and gray silty clay loam and silty clay. Spots and streaks of gypsum and other salts are throughout the profile.

James soils have high organic-matter content and medium fertility. Permeability is slow, and the available water capacity is low or moderate. These soils are subject to flooding and have a seasonal high water table within 2 feet of the surface.

Many areas are used for crops, but some areas remain in native vegetation and are used for hay and pasture. A few areas are wooded.

Representative profile of James silty clay, in cultivation, 150 feet west and 2,450 feet north of the southeast corner of sec. 28, T. 92 N., R. 50 W.

Apsa—0 to 6 inches; dark gray (5Y 4/1) silty clay, black (N 2/0) moist; moderate fine subangular blocky structure; very hard, firm, sticky and plastic; few freshwater snail fragments; common fine segregations of salt; slight effervescence; moderately alkaline; abrupt smooth boundary.

A12sa—6 to 19 inches; dark gray (5Y 4/1) silty clay, black (N 2/0) moist; few medium faint gray mottles, moist; weak coarse subangular blocky structure parting to weak medium and fine subangular blocky; hard, firm, sticky and plastic; few freshwater snail fragments; common fine nests and crystals of gypsum; many fine segregations of salt; slight effervescence; moderately alkaline; gradual wavy boundary.

A13gcs—19 to 25 inches; dark gray (5Y 4/1) silty clay, black (5Y 2/1) moist; few medium faint gray mottles, moist, and common fine prominent strong brown (7.5YR 5/6) mottles, moist; weak medium and fine subangular blocky structure; very hard, firm, sticky and plastic; many fine and medium nests of gypsum; few fine segregations of salt; slight effervescence; moderately alkaline; gradual wavy boundary.

A14gcs—25 to 30 inches; dark gray (5Y 4/1) silty clay, very dark gray (5Y 3/1) moist; many fine and medium distinct olive brown (2.5Y 4/3) mottles, moist, and common fine distinct strong brown (7.5YR 5/6) mottles, moist; massive; very hard, firm, sticky and plastic; common medium nests of gypsum; slight effervescence; moderately alkaline; gradual wavy boundary.

C1g—30 to 39 inches; light olive gray (5Y 6/2) silty clay loam, olive gray (5Y 4/2) moist; many fine and medium distinct strong brown (7.5YR 5/6) mottles, moist, and common fine distinct dark reddish brown (5YR 2/2) mottles, moist; massive; very hard, firm, sticky and plastic; few medium nests of gypsum; slight effervescence; moderately alkaline; gradual wavy boundary.

C2g—39 to 60 inches; gray (5Y 5/1) and light olive gray (5Y 6/2) silty clay, dark gray (5Y 4/1) and olive gray (5Y 4/2) moist; many fine and medium distinct strong brown (7.5YR 5/6) mottles, moist, and common fine distinct dark reddish brown (5YR 2/2) mottles, moist; massive; very hard, firm, sticky and plastic; common fine segregations of lime; strong effervescence; moderately alkaline.

Free carbonates are within 10 inches of the surface. Buried soils are below a depth of 20 inches in some pedons. Conductivity ranges from 4 to 20 millimhos in the upper horizons. The A horizon is dark gray or very dark gray silty clay or heavy silty clay loam 18 to 30 inches thick. It ranges from mildly alkaline to strongly alkaline. Some pedons have a B2g horizon. The C horizon ranges from dark gray to light olive gray in a hue of 2.5Y or 5Y. It is silty clay loam, silty clay, or clay.

James soils are near Forney, Luton, and Salmo soils. James soils have more salts than Forney and Luton soils and are more clayey than Salmo soils.

Ja—James silty clay. This is a level soil in meander scars and swales on bottom lands along the Missouri River. Slopes are 0 to 1 percent. The areas are long and narrow and are mostly less than 40 acres in size.

Included with this soil in mapping are small areas of Salmo soils on slightly raised humps and low ridges.

Runoff is very slow or is ponded in some areas. Wetness commonly delays planting and tillage, and in some years the soil is too wet to farm. This soil dries slowly, and it compacts and loses its tilth if farmed when wet. Overcoming wetness caused by flooding and a high water table, managing the high content of salts, and maintaining tilth are the main concerns of management if this soil is farmed.

Many areas are used for crops, but some are used for hay and pasture. This soil is better suited to late-planted crops such as corn, soybeans, and sorghum than to small grain. Capability unit IVw-2, pasture group J, windbreak group 10.

Kennebec Series

The Kennebec series consists of deep, moderately well drained, nearly level, silty soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses and some stringers of trees and shrubs along streams channels.

In a representative profile (fig. 8) the surface layer is dark gray silty clay loam about 33 inches thick. Below that is dark grayish brown silty clay loam about 8 inches thick. The underlying material to a depth of 50 inches is grayish brown silty clay loam. Below this is grayish brown loam that is stratified with a few lenses of fine sand.

Figure 8.—**Representative profile of Kennebec silty clay loam.**

Kennebec soils have high fertility and high organic-matter content. Permeability is moderate, and the available water capacity is high. These soils occasionally are flooded and have a seasonal water table at a depth of 3 to 5 feet.

Most areas are cultivated but a few areas remain in native grass and are used for grazing or hay.

Representative profile of Kennebec silty clay loam, in cultivation, 126 feet west and 300 feet north of the center of sec. 2, T. 92 N., R. 49 W.

Ap—0 to 7 inches; dark gray (10YR 4/1) silty clay loam, very dark brown (10YR 2/2) moist; weak medium subangular blocky structure parting to weak fine granular; hard, friable, slightly sticky and slightly plastic; neutral; abrupt smooth boundary.

A12—7 to 19 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak medium subangular blocky structure parting to weak fine granular; slightly hard, friable, slightly sticky and slightly plastic; common fine pores; neutral; gradual smooth boundary.

A13—19 to 33 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; moderate fine subangular blocky structure; slightly hard, friable, slightly sticky and slightly plastic; common fine pores; neutral; gradual smooth boundary.

AC—33 to 41 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; moderate fine subangular blocky structure; hard, friable, slightly sticky and slightly plastic; neutral; gradual smooth boundary.

C1—41 to 50 inches; grayish brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; many fine distinct dark reddish brown (5YR 3/2) and strong brown (7.5YR 5/6) mottles, moist; weak fine subangular blocky structure; slightly hard, friable; neutral; gradual smooth boundary.

C2—50 to 60 inches; grayish brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) moist; many fine distinct dark reddish brown (5YR 3/2) and strong brown (7.5YR 5/6) mottles, moist, and many fine faint dark gray mottles, moist; massive; slightly hard, very friable; few thin lenses of fine sand; neutral.

Depth to free carbonates ranges from 45 to 60 inches or more. The A horizon commonly ranges from very dark gray to dark grayish brown, but it is grayish brown in places that have recent overwash on the surface. The A horizon is silty clay loam or silt loam and is 27 to 40 inches thick. The upper part of the C horizon commonly is silty clay loam or silt loam, but the lower part ranges from fine sandy loam to silty clay loam. Mottles in the C horizon range from few to many.

Kennebec soils are near Alcester, Benclare, Calco, Davis, and McPaul soils. Kennebec soils are leached of free carbonates to greater depths than Alcester and McPaul soils. They are better drained than Benclare and Calco soils. They contain less sand and are more silty than Davis soils.

Ka—Kennebec silty clay loam. This is a nearly level soil on bottom lands along streams (fig. 9) and drainageways. Slopes are 0 to 2 percent. The areas along drainageways are long and narrow, but the areas along streams range to several hundred acres in size.

Included with this soil in mapping are small areas of Benclare, Davis, McPaul, and Salix soils. In areas along the Big Sioux River, Benclare soils are in narrow meander scars and swales, and Davis and Salix soils are on very slight rises.

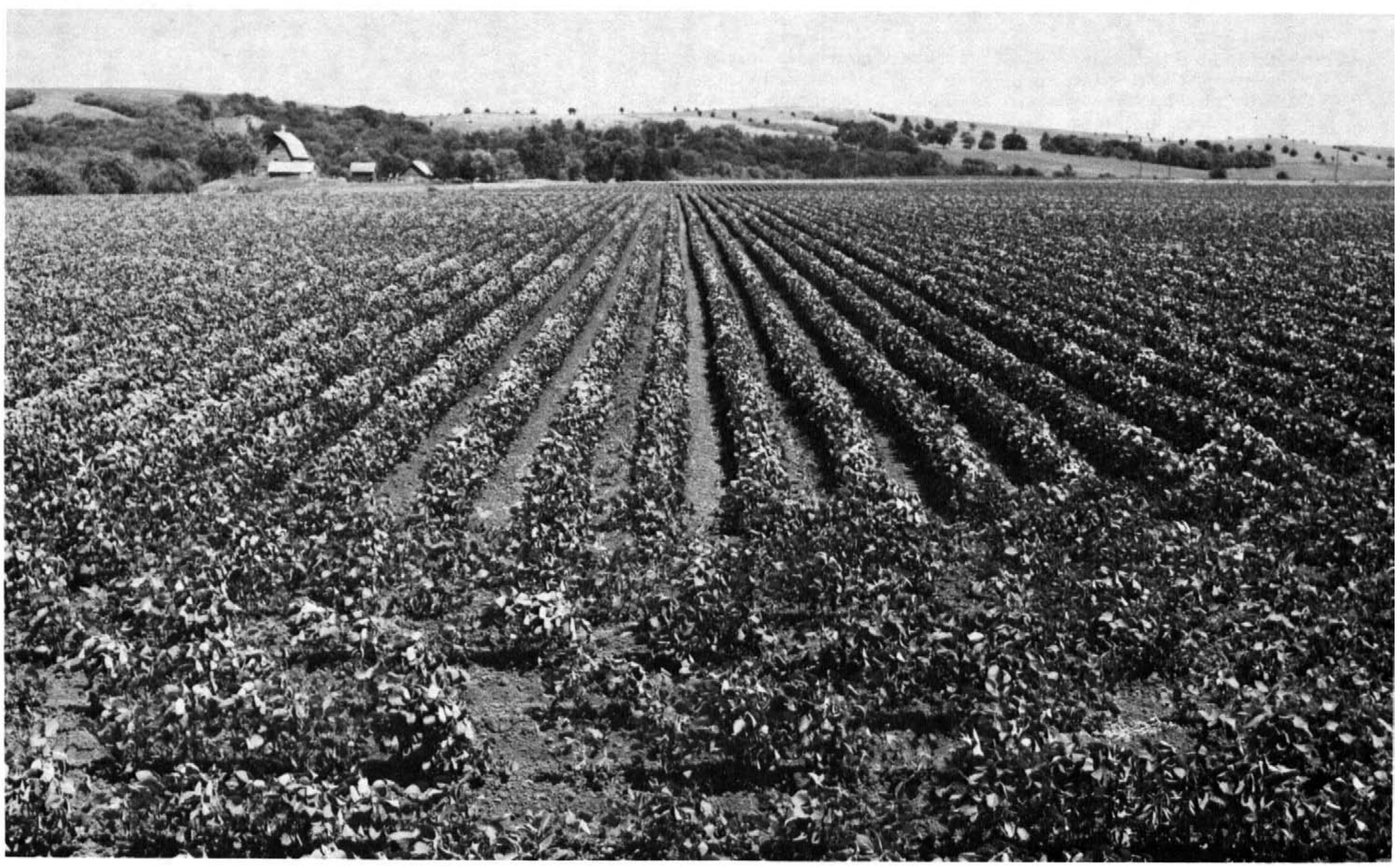

Figure 9.—**An area of Kennebec silty clay loam.**

McPaul soils are in places where recent overwash has accumulated, mainly along fencelines and roadsides.

Runoff is slow. This soil is flooded from stream overflow in some years and generally receives some runoff from adjacent uplands. In most years the additional moisture is beneficial, however, and the limitations for crops are slight.

Almost all areas are used for crops. Corn, soybeans, and alfalfa are the main crops. Capability unit I–1, pasture group K, windbreak group 1.

Lakeport Series

The Lakeport series consists of deep, somewhat poorly drained, nearly level, silty soils on high bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is dark grayish brown and grayish brown silty clay loam about 15 inches thick. The subsoil is grayish brown and is about 27 inches thick. The upper part is silty clay loam, and the lower part is silty clay. The underlying material is grayish brown and light brownish gray, stratified silty clay loam and silty clay that contains thin lenses of silt loam.

Lakeport soils have high fertility and high organic-matter content. Permeability is moderately slow, and the available water capacity is moderate or high. These soils have a seasonal high water table at a depth of 2 to 4 feet.

Almost all areas are used for crops, and some are irrigated. A few areas are used for pasture and hay.

Representative profile of Lakeport silty clay loam, in cultivation, 135 feet west and 246 feet south of the northeast corner of sec. 19, T. 91 N., R. 50 W.

Ap—0 to 7 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; weak fine subangular blocky structure; slightly hard, friable, sticky and plastic; neutral; abrupt smooth boundary.

A12—7 to 15 inches; grayish brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) and dark grayish brown (2.5Y 4/2) moist; weak medium subangular blocky structure parting to moderate fine subangular blocky; hard, friable, slightly sticky and slightly plastic; neutral; gradual smooth boundary.

B21—15 to 25 inches; grayish brown (2.5Y 5/2) silty clay loam, very dark grayish brown (2.5Y 3/2) crushing to dark grayish brown (2.5Y 4/2) moist; common medium distinct black (10YR 2/1) mottles, moist, and common fine distinct dark brown (7.5YR 4/4) mottles, moist; weak medium subangular blocky structure parting to moderate fine and very fine subangular blocky; hard, firm, sticky and plastic; many very fine inped tubular pores; neutral; gradual smooth boundary.

B22—25 to 36 inches; grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; common medium distinct brown (7.5YR 5/4) mottles and few fine distinct black (10YR 2/1) mottles, moist; moderate fine subangular blocky structure; hard, firm, sticky and plastic; few fragments of snail shells; thin lenses of calcareous silt loam; neutral; gradual smooth boundary.

B3—36 to 42 inches; grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; common fine distinct strong brown (7.5YR 5/6) mottles, moist; many fine distinct light olive brown (2.5Y 5/4) mottles, moist; few fine faint dark gray mottles, moist; weak fine subangular blocky structure; hard, firm, sticky and plastic; thin lenses of silt loam; slight effervescence; mildly alkaline; gradual smooth boundary.

C—42 to 60 inches; grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) stratified silty clay and silty clay loam and thin lenses of silt loam, dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) moist; many fine distinct brown (7.5YR 5/4) mottles, moist, and common medium faint dark gray mottles, moist; massive; very hard, firm, sticky and plastic; strong effervescence; mildly alkaline.

Clay content of the solum ranges from 35 to 42 percent. The A horizon ranges from dark gray to grayish brown and is 12 to 18 inches thick. The B horizon is dark grayish brown or grayish brown in a hue of 2.5Y or 10YR. It is 18 to 32 inches thick. The C horizon commonly is silty clay or silty clay loam, but in places it is silt loam or very fine sandy loam below a depth of 40 inches.

Lakeport soils in Union County differ from the defined range of the series because they have fine stratification in the B and C horizons, but this difference does not alter their usefulness or behavior.

Lakeport soils are near Blencoe, Blyburg, Forney, Omadi, and Salix soils. Lakeport soils have a less clayey A horizon than Blencoe soils but are more clayey below a depth of 20 to 30 inches. Lakeport soils are more clayey than Blyburg and Omadi soils. They are better drained than Forney soils and have a more clayey B horizon than Salix soils.

La—Lakeport silty clay loam. This is a nearly level soil on high bottom lands in irregularly shaped areas that range to 200 or more acres in size. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Blencoe and Omadi soils. Blencoe soils are in slightly concave low areas, and Omadi soils are on very slight rises.

Runoff is slow. Wetness from a seasonal high water table delays farming in some years. This soil compacts and loses its tilth if farmed when wet. Overcoming wetness and maintaining tilth are the main concerns of management.

This soil is well suited to all crops commonly grown in the county. Almost all areas are used for crops. Corn and soybeans are the main crops. Capability unit IIw–1, pasture group A, windbreak group 2.

Lamo Series

The Lamo series consists of deep, somewhat poorly drained, level, silty soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses and some stringers of native trees and shrubs along stream channels.

In a representative profile the surface layer is calcareous, dark gray silty clay loam about 17 inches thick. Below this is calcareous, dark gray silty clay loam about 13 inches thick. The underlying material is calcareous, gray silty clay loam.

Lamo soils have high fertility and high organic-matter content. Permeability is moderately slow, and the available water capacity is high. These soils are subject to flooding and have a seasonal water table at a depth of 2 to 5 feet.

Most areas are used for crops. A few areas are in native or tame grass and are used for pasture or hay.

Representative profile of Lamo silty clay loam, in cultivation, 120 feet east and 1,280 feet south of the northwest corner of sec. 4, T. 95 N., R. 48 W.

Ap—0 to 8 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; moderate very fine granular structure; slightly hard, friable, slightly sticky; strong effervescence; moderately alkaline; abrupt smooth boundary.

A12—8 to 17 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak fine subangular blocky structure parting to moderate very fine granular; slightly hard, friable, slightly sticky; strong effervescence; moderately alkaline; gradual wavy boundary.

AC—17 to 30 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; few fine distinct dark yellowish brown (10YR 4/4) mottles, moist; moderate medium subangular blocky structure parting to moderate fine subangular blocky; slightly hard, friable, slightly sticky; few fragments of snail shells; strong effervescence; moderately alkaline; gradual wavy boundary.

C1g—30 to 45 inches; gray (5Y 5/1) silty clay loam, very dark

gray (5Y 3/1) moist; common medium and coarse distinct light olive brown (2.5Y 5/4) mottles, moist; moderate medium and fine subangular blocky structure; hard, firm, slightly sticky and slightly plastic; common visible sand grains; few fine segregations of lime; strong effervescence; moderately alkaline; clear wavy boundary.

C2g—45 to 50 inches; gray (5Y 5/1) silty clay loam, very dark gray (5Y 3/1) moist; many coarse distinct light olive brown (2.5Y 5/4) mottles, moist, and few medium distinct dark reddish brown (5YR 3/2) mottles, moist; weak coarse subangular blocky structure; very hard, firm, sticky and plastic; common fine segregations and few fine concretions of lime; strong effervescence; moderately alkaline; clear wavy boundary.

C3g—50 to 60 inches; gray (5Y 5/1) silty clay loam, very dark gray (5Y 3/1) moist; common fine and medium distinct yellowish red (5YR 4/8) mottles, moist; massive; hard, firm, sticky and plastic; common fine segregations of lime; strong effervescence; moderately alkaline.

Free carbonates are at the surface or within a depth of 8 inches. The A horizon is dark gray or very dark gray in a hue of 10YR or 2.5Y, and it is silty clay loam or silt loam 14 to 20 inches thick. Some pedons lack an AC horizon. The C horizon commonly is dark gray, but in places the lower part is gray. It is dominantly silty clay loam, but in places the lower part is silty clay and in places gravelly sand is below 40 inches.

Lamo soils are on bottom lands, as are Alcester, Benclare, Calco, Davis, Kennebec, and McPaul soils. Lamo soils are more poorly drained than Alcester, Davis, Kennebec, and McPaul soils. They contain less clay and are more calcareous than Benclare soils. They are better drained than Calco soils.

Lb—Lamo silty clay loam. This is a level soil on bottom lands in areas that range to 250 acres in size. Slopes are 0 to 1 percent.

Included with this soil in mapping are small areas of Kennebec soils. They generally are on the edges of the areas slightly above the Lamo soil.

Runoff is slow. Wetness that results from flooding and from a seasonal high water table delays farming in some years, but in most areas drainage is adequate for intensive cropping. This soil compacts and loses its tilth if farmed when wet. Overcoming wetness and maintaining tilth are the main concerns of management.

Most areas are used for crops. If adequately drained, this soil is well suited to all crops commonly grown in the county. Corn, soybeans, and alfalfa are the main crops. Capability unit IIw-3, pasture group A, windbreak group 2.

Luton Series

The Luton series consists of deep, poorly drained, level, clayey soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is silty clay about 18 inches thick. It is very dark gray in the upper part and black in the lower part. The subsoil is silty clay about 18 inches thick. It is very dark gray in the upper part, dark gray in the middle, and olive gray and dark gray in the lower part. The underlying material is calcareous, olive gray and gray silty clay.

Luton soils have high fertility and high organic-matter content. Permeability is very slow, and the available water capacity is low or moderate. Luton soils are occasionally flooded and have a seasonal high water table at a depth of 1 to 3 feet.

Most areas are used for crops. A few areas are used for pasture or hay.

Representative profile of Luton silty clay, in cultivation, 1,200 feet west and 1,120 feet north of the southeast corner of sec. 5, T. 91 N., R. 49 W.

Ap—0 to 6 inches; very dark gray (5Y 3/1) silty clay, black (N 2/0) moist; weak medium subangular blocky structure; very hard, firm, sticky and plastic; neutral; abrupt smooth boundary.

A12—6 to 18 inches; black (5Y 2/1) silty clay, black (N 2/0) moist; weak medium subangular blocky structure parting to moderate fine and very fine blocky; very hard, firm, sticky and plastic; neutral; gradual wavy boundary.

B21g—18 to 24 inches; very dark gray (5Y 3/1) silty clay, black (5Y 2/1) moist; few fine and medium distinct light olive brown (2.5Y 5/4) mottles, moist; weak coarse subangular blocky structure parting to moderate fine and very fine blocky; extremely hard, very firm, sticky and plastic; common shiny pressure faces; neutral; gradual wavy boundary.

B22g—24 to 30 inches; dark gray (5Y 4/1) silty clay, very dark gray (5Y 3/1) moist; few fine distinct light olive brown (2.5Y 5/4) mottles, moist, and common fine faint olive mottles, moist; weak medium subangular blocky structure parting to moderate fine blocky; extremely hard, very firm, sticky and plastic; common shiny pressure faces; neutral; clear wavy boundary.

B3g—30 to 36 inches; olive gray (5Y 4/2) and dark gray (5Y 4/1) silty clay, dark olive gray (5Y 3/2) and very dark gray (5Y 3/1) moist; common fine faint olive mottles, moist; moderate medium subangular blocky structure; extremely hard, very firm, sticky and plastic; common shiny pressure faces; few fine concretions of lime; neutral; gradual wavy boundary.

C1g—36 to 46 inches; olive gray (5Y 5/2) and gray (5Y 5/1) silty clay, olive gray (5Y 4/2) and dark gray (5Y 4/1) moist; common fine distinct light olive brown (2.5Y 5/4) mottles, moist, and common fine faint black mottles, moist; weak coarse and medium subangular blocky structure; extremely hard, very firm, sticky and plastic; common fragments of snail shells; common fine and medium concretions of lime; slight effervescence; neutral; gradual wavy boundary.

C2g—46 to 60 inches; olive gray (5Y 5/2) and gray (5Y 5/1) silty clay, olive gray (5Y 4/2) and dark gray (5Y 4/1) moist; common fine distinct yellowish brown (10YR 5/6) mottles, moist, and many medium and coarse faint gray mottles, moist; massive; extremely hard, very firm, sticky and plastic; few fragments of snail shells; common fine concretions of lime; slight effervescence; mildly alkaline.

Depth to free carbonates commonly is more than 36 inches, but secondary carbonates are in the lower part of the B horizon in some pedons. The A horizon commonly is silty clay or clay 14 to 24 inches thick, but it is silty clay loam or silt loam in places where recent overwash has accumulated. Some pedons have an A3 horizon. The B horizon is silty clay or clay. The B3 and C horizons range from dark gray to olive. The C horizon commonly is silty clay, but in places it is clay or silty clay loam. In places layers of sand are at a depth of 40 to 60 inches.

Luton soils are near Benclare, Blencoe, Forney, Kennebec, and Salix soils. Luton soils are more poorly drained and more clayey than Benclare, Kennebec, and Salix soils. They have more clayey B3 and C horizons and are more poorly drained than Blencoe soils. They have thicker A and B horizons than Forney soils.

Ld—Luton silty clay. This is a level soil on bottom lands along large streams. Slopes are 0 to 1 percent. This soil has the profile described as representative of the series, but in places the lower part of the subsoil is calcareous, and in some areas along the Big Sioux River a thin overwash of silt loam or silty clay loam is on the surface.

Included with this soil in mapping are small areas of Benclare and Blencoe soils on very slight rises.

Runoff is slow. Wetness that results from flooding and from a seasonal high water table commonly delays planting in spring. In wet years this soil is difficult to farm; however, most areas are suitable for crops because drainage has been improved. This soil dries slowly, and it compacts and loses its tilth if farmed when wet. Overcoming wetness and maintaining tilth are the main concerns of management.

Most areas are used for crops. This soil is best suited to

late-planted crops such as corn and soybeans. Alfalfa and some winter wheat also are grown. Capability unit IIIw–2, pasture group A, windbreak group 2.

McPaul Series

The McPaul series consists of deep, moderately well drained, nearly level, silty soils on bottom lands. These soils formed in recent alluvium washed from adjoining uplands. The native vegetation consisted mainly of tall grasses, but stringers of native trees were common along stream channels.

In a representative profile the surface layer is calcareous, grayish brown silt loam about 6 inches thick. The underlying material to a depth of 41 inches is calcareous, grayish brown and pale brown silt loam. Below this it is dark gray silty clay loam.

McPaul soils have moderately low organic-matter content and medium fertility. Permeability is moderate, and the available water capacity is high. These soils are occasionally flooded and have a seasonal water table at a depth of 3 to 5 feet.

Most areas are used for crops. Some narrow areas are dissected by channels and are used for pasture.

Representative profile of McPaul silt loam, in cultivation, 520 feet south and 1,130 feet west of the northeast corner of sec. 34, T. 94 N., R. 49 W.

Ap—0 to 6 inches; grayish brown (10YR 5/2) silt loam, dark grayish brown (10YR 4/2) moist; weak fine granular structure; soft, very friable; slight effervescence; mildly alkaline; abrupt smooth boundary.

C—6 to 41 inches; grayish brown (10YR 5/2) and pale brown (10YR 6/3) silt loam, dark grayish brown (10YR 4/2) and brown (10YR 5/3) moist; massive, laminations evident; slightly hard, friable; slight effervescence; mildly alkaline; clear wavy boundary.

IIAb—41 to 60 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; few fine faint gray mottles, moist; moderate medium subangular blocky structure; hard, friable, slightly sticky; neutral.

Depth to a buried soil commonly is 35 to 45 inches but ranges from 24 to 60 inches. The horizons above the buried soil average grayish brown to pale brown and commonly are stratified with thin layers of dark grayish brown. The A horizon is 6 to 10 inches thick. The C horizon above the buried soil is less than 18 percent clay. It is mildly alkaline or moderately alkaline. The Ab horizon ranges from very dark gray to dark grayish brown in a hue of 10YR or 2.5Y and has few to many mottles. It is silty clay loam or silt loam, but in places it is stratified with thin lenses of silty clay below a depth of 40 inches. The Ab horizon commonly is neutral or slightly acid, but in places it is mildly alkaline or moderately alkaline and is calcareous. Some pedons lack an Ab horizon.

McPaul soils are near Alcester, Calco, Kennebec, and Lamo soils and are similar to Haynie soils. McPaul soils have a thinner A horizon and are shallower to lime than Alcester and Kennebec soils. They are better drained and have a thinner A horizon than Calco and Lamo soils. They have less sand in the C horizon than Haynie soils.

Ma—McPaul silt loam. This is a nearly level soil that is mainly in narrow stream valleys and also on some irregularly shaped fans where the narrow valleys merge into larger stream bottoms. Slopes are 0 to 2 percent.

Included with this soil in mapping are small areas of Alcester, Kennebec, and Lamo soils. Alcester and Kennebec soils are on the edges of the mapped areas. Lamo soils are in concave low areas. In places these included soils have an overwash of grayish brown, calcareous silt loam.

Runoff is slow, and the hazards of erosion and soil blowing are slight. This soil is subject to flooding mainly early in spring before the crops start growing. In some years, however, intensive rain during the growing season results in the deposition of sediment and debris in places. Still, in most years the flooding damage is slight, and this soil has few limitations for crops. Maintaining fertility is the main concern of management.

Most areas are used for crops. This soil is well suited to all crops commonly grown in the county. Capability unit I–1, pasture group F, windbreak group 1.

Modale Series

The Modale series consists of deep, moderately well drained, nearly level, silty soils that are underlain by silty clay. These soils are on bottom lands. They formed in alluvium. The native vegetation consisted mainly of tall grasses and deciduous trees.

In a representative profile the surface layer is calcareous, grayish brown silt loam about 7 inches thick. The underlying material, to a depth of 24 inches, is calcareous, light brownish gray silt loam and very fine sandy loam. Below this it is calcareous, grayish brown silty clay.

Modale soils have moderately low organic-matter content and medium fertility. Permeability is moderate in the silty upper part of the profile but very slow in the clayey lower part. The available water capacity is moderate. A seasonal high water table is at a depth of 1 to 3 feet, and some areas are subject to flooding.

Most areas are used for crops and some are irrigated. A few areas remain in native vegetation and are used for pasture and hay.

Representative profile of Modale silt loam, in cultivation, 87 feet west and 825 feet south of the northeast corner of sec. 29, T. 90 N., R. 49 W.

Ap—0 to 7 inches; grayish brown (2.5Y 5/2) silt loam, dark grayish brown (2.5Y 4/2) moist; weak fine granular structure; soft, very friable; strongly effervescent; mildly alkaline; abrupt smooth boundary.

C1—7 to 11 inches; light brownish gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist; few fine distinct strong brown (7.5YR 5/6) mottles, moist; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; soft, very friable; strong effervescence; mildly alkaline; clear smooth boundary

C2—11 to 24 inches; light brownish gray (2.5Y 6/2) very fine sandy loam, dark grayish brown (2.5Y 4/2) moist; common medium distinct yellowish brown (10YR 5/4), strong brown (7.5YR 5/6), and dark gray (5Y 4/1) mottles, moist; massive, laminations evident; soft, very friable; strong effervescence; moderately alkaline; abrupt smooth boundary.

IIC3g—24 to 60 inches; grayish brown (2.5Y 5/2) silty clay, dark grayish brown (2.5Y 4/2) moist; common fine and medium distinct strong brown (7.5YR 5/6), dark gray (5Y 4/1), and yellowish brown (10YR 5/4) mottles, moist; weak fine blocky structure; very hard, very firm, sticky and plastic; 1-inch thick layer of black (10YR 2/1) silty clay at about 28 inches; 1-inch thick lens of silt loam at about 36 inches; slight effervescence; mildly alkaline.

Thickness of the horizons above the IIC horizon ranges from 18 to 30 inches. The A horizon ranges from dark gray to grayish brown in a hue of 2.5Y or 10YR. It commonly is silt loam, but in places it is silty clay loam or very fine sandy loam. In places the A horizon is noncalcareous. It is 6 to 10 inches thick. The C horizon commonly is stratified with thin layers of coarser or finer textured material. The IIC horizon is silty clay or clay.

Modale soils are near Albaton, Forney, Grable, Haynie, Onawa, and Percival soils. Modale soils are better drained and less clayey in the A horizon and upper part of the C horizon than Albaton, Forney, Onawa, and Percival soils. Within a depth of 30 inches, Modale soils are more clayey than Grable and Haynie soils.

Mb—Modale silt loam. This is a nearly level soil on wide bottom lands along the major streams. Slopes are 0 to 2 percent. In most areas this soil has the profile described as representative of the series, but in some areas along the Big Sioux River the underlying material is silty clay loam, and in a few places the depth to clayey material is slightly more than 30 inches.

Included with this soil in mapping are small areas of Albaton and Haynie soils. Albaton soils are in swales and low areas and commonly have a thin overwash of silt loam. Haynie soils are on slight rises.

Runoff is slow. This soil has a seasonal high water table, and some areas are subject to flooding. In most years, however, the additional moisture is beneficial, and the limitations for crops are slight. Maintaining fertility is the main concern of management.

This soil is well suited to all crops commonly grown in the county. Corn, soybeans, and alfalfa are the main crops. Some areas are irrigated. Capability unit I–1, pasture group K, windbreak group 1.

Moody Series

The Moody series consists of deep, well drained, nearly level to sloping, silty soils on uplands. These soils formed in loess. The native vegetation consisted mainly of mid and tall grasses.

In a representative profile the surface layer is dark grayish brown silty clay loam about 7 inches thick. The subsoil is about 32 inches thick. It is dark grayish brown silty clay loam in the upper part, brown and pale brown silty clay loam in the middle, and pale brown silt loam in the lower part. The underlying material is calcareous, light yellowish brown silt loam.

Moody soils have high fertility and high organic-matter content. Permeability is moderate, and the available water capacity is high.

Almost all areas are used for crops. A few small areas are used for pasture and hay.

Representative profile of Moody silty clay loam, 2 to 6 percent slopes, in cultivation, 172 feet west and 102 feet south of the northeast corner of sec. 2, T. 94 N., R. 49 W.

Ap—0 to 7 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; weak medium subangular blocky structure parting to weak fine granular; slightly hard, friable, slightly sticky; slightly acid; abrupt smooth boundary.

B21—7 to 12 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak medium prismatic structure parting to weak medium and fine subangular blocky; slightly hard, friable, slightly sticky; many worm casts; slightly acid; clear wavy boundary.

B22—12 to 21 inches; brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; weak medium prismatic structure parting to moderate medium subangular blocky; slightly hard, friable, slightly sticky and slightly plastic; common worm casts; faint clay films in voids and as patches on faces of peds; slightly acid; gradual wavy boundary.

B23—21 to 33 inches; pale brown (10YR 6/3) silty clay loam, dark yellowish brown (10YR 4/4) moist; weak medium prismatic structure parting to weak medium subangular blocky; slightly hard, friable, slightly sticky; faint clay films in voids and as patches on faces of peds; slightly acid; gradual wavy boundary.

B3—33 to 39 inches; pale brown (10YR 6/3) silt loam, yellowish brown (10YR 5/4) moist; few fine distinct strong brown (7.5YR 5/6) mottles, moist, and few fine faint gray mottles, moist; weak coarse prismatic structure parting to weak coarse and medium subangular blocky; slightly hard, friable; slightly acid; clear wavy boundary.

C1ca—39 to 50 inches; light yellowish brown (2.5Y 6/3) silt loam, light olive brown (2.5Y 5/3) moist; common medium distinct gray (5Y 5/1) mottles, moist, and common fine distinct strong brown (7.5YR 5/6) mottles, moist; weak coarse and medium subangular blocky structure; slightly hard, very friable; common fine concretions and segregations of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C2—50 to 60 inches; light yellowish brown (2.5Y 6/3) silt loam, light olive brown (2.5Y 5/3) moist; common fine distinct gray (5Y 5/1), strong brown (7.5YR 5/6), and very dark brown (10YR 2/2) mottles, moist; massive; slightly hard, very friable; few fine segregations of lime; strong effervescence; moderately alkaline.

Depth to lime ranges from 30 to 50 inches. The A horizon is dark grayish brown or very dark grayish brown and is 6 to 10 inches thick. Some pedons have a thin B1 horizon. The B21 horizon is dark grayish brown or grayish brown and is 4 to 7 inches thick. The rest of the B horizon ranges from brown to light yellowish brown in a hue of 10YR or 2.5Y. The B3 horizon is calcareous in some pedons.

Moody soils are mapped with or are near Alcester, Crofton, and Nora soils, and they are similar to Wentworth soils. Moody soils have a thinner A horizon than Alcester soils and are deeper to lime than Crofton and Nora soils. Moody soils have a more uniformly silty C horizon than Wentworth soils.

McA—Moody silty clay loam, 0 to 2 percent slopes. This nearly level soil is on uplands in irregularly shaped areas that range from 5 to 40 acres in size. Slopes are plane to concave. The surface layer is slightly thicker and the depth to lime is greater than that in the profile described as representative of the series.

Included with this soil in mapping are small areas of Alcester soils in shallow swales.

Runoff is slow, and the hazards of erosion and soil blowing are slight. This Moody soil has few if any limitations for crops. Maintaining fertility is the main concern of management.

Almost all areas are used for crops. Corn, oats, soybeans, and alfalfa are the main crops. Capability unit I–2, pasture group F, windbreak group 3.

McB—Moody silty clay loam, 2 to 6 percent slopes. This gently sloping soil is on uplands in irregularly shaped areas that range to 400 acres in size. Slopes are long and smooth. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Alcester and Nora soils. Alcester soils are on the lower part of the landscape along drainageways, and Nora soils are on the tops and upper sides of ridges and knolls.

Runoff is medium, and the hazard of erosion is moderate. Controlling erosion is the main concern of management.

Almost all areas are cultivated, and this soil is well suited to all crops grown in the county. Corn, oats, soybeans, and alfalfa are the main crops. Capability unit IIe–3, pasture group F, windbreak group 3.

MdC—Moody-Nora silty clay loams, 6 to 10 percent slopes. This complex is about 50 percent Moody soil, 35 percent Nora soil, and 15 percent other soils. The areas are irregularly shaped and range to 800 acres in size. Slopes are convex, long, and smooth (fig. 10). The Moody soil is on the mid and lower parts of the landscape, and the Nora soil is on the tops and upper sides of ridges and knolls. This Moody soil is slightly shallower to lime than the Moody soil described as representative of the series. The Nora soil has the profile described as representative of the Nora series, but in eroded

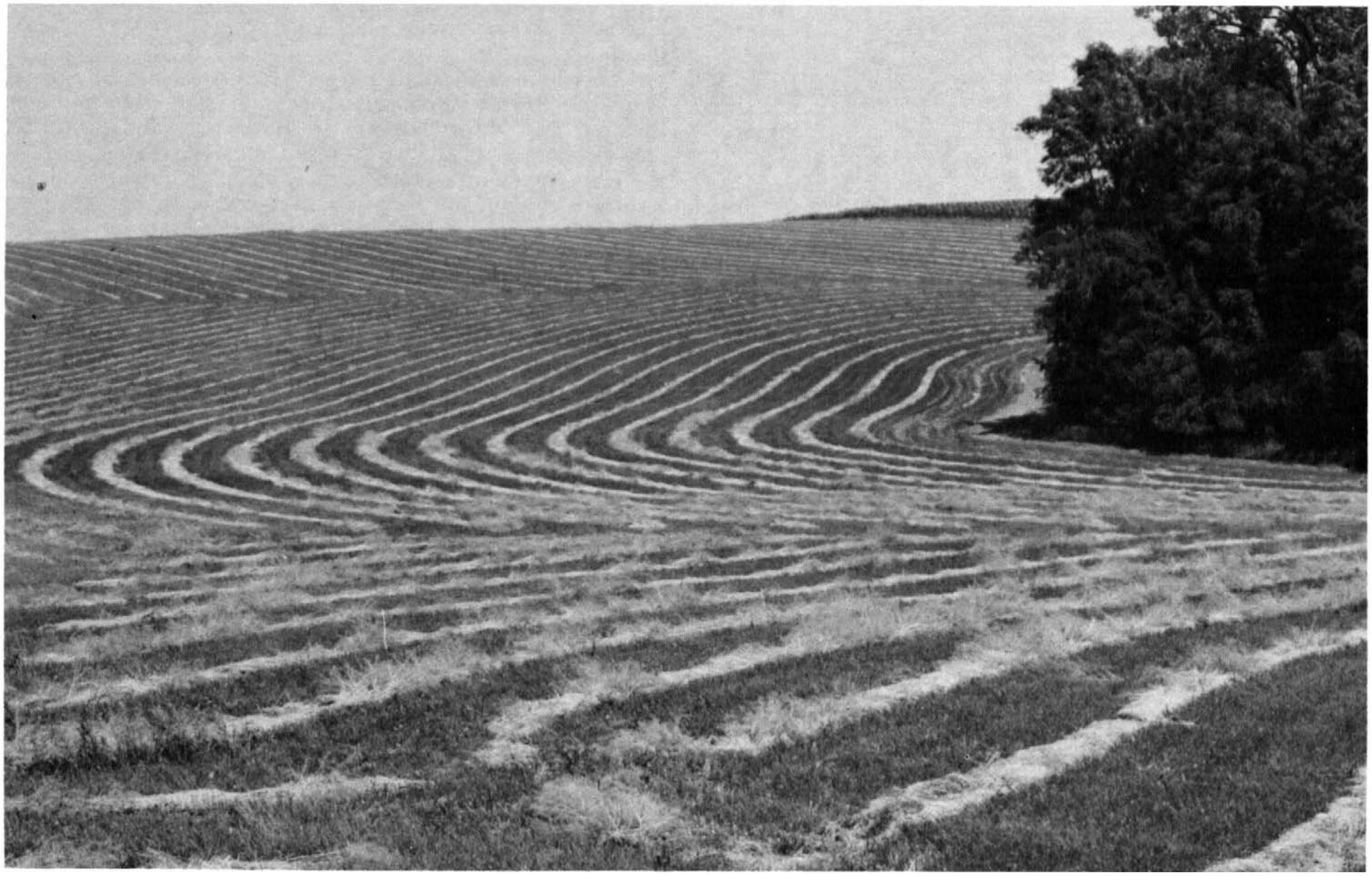

Figure 10.—**An area of Moody-Nora silty clay loams, 6 to 10 percent slopes.**

areas the surface layer is grayish brown because it has been mixed with the subsoil in plowing.

Included with these soils in mapping are small areas of Alcester and Crofton soils. Alcester soils are on foot slopes along drainageways, and Crofton soils are on ridgetops and knolls.

Runoff is medium, and the hazard of erosion is severe. Controlling erosion is the main concern of management.

Most areas are used for crops, but some areas are used for pasture and hay. These soils are well suited to all crops grown in the county. Corn, oats, and alfalfa are the main crops. Capability unit IIIe–2, pasture group F, windbreak group 3.

Nora Series

The Nora series consists of deep, well drained, gently sloping to very steep, silty soils on uplands. These soils formed in loess. The native vegetation consisted mainly of tall and mid grasses, but trees and shrubs were in some areas.

In a representative profile (fig. 11) the surface layer is dark grayish brown silty clay loam about 8 inches thick. The subsoil is silt loam about 22 inches thick. It is brown in the upper part and calcareous and light yellowish brown in the lower part. The underlying material is calcareous, light yellowish brown silt loam.

Nora soils have moderate organic-matter content and medium fertility. Permeability is moderate, and the available water capacity is high.

Many areas are cultivated. Some areas are in tame grasses and are used for hay and pasture. Steep areas remain in native vegetation and are used for pasture.

Representative profile of Nora silty clay loam, in an area of Moody-Nora silty clay loams, 6 to 10 percent slopes, in cultivation, 2,355 feet north and 230 feet west of the southeast corner of sec. 11, T. 94 N., R. 49 W.

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable; slightly acid; abrupt smooth boundary.

B21—8 to 12 inches; brown (10YR 5/3) silt loam, dark brown (10YR 4/3) moist; weak coarse prismatic structure parting to weak medium and fine subangular blocky; slightly hard, friable; common fine and very fine pores; common worm casts; slightly acid; gradual wavy boundary.

B22—12 to 20 inches; brown (10YR 5/3) silt loam, dark brown (10YR 4/3) moist; weak coarse prismatic structure parting to weak coarse and medium subangular blocky; slightly hard, friable; common fine pores; few worm casts; neutral; clear wavy boundary.

B3ca—20 to 30 inches; light yellowish brown (2.5Y 6/3) silt loam, light olive brown (2.5Y 5/4) moist; few fine distinct gray (5Y 5/1) mottles, moist; weak very coarse and coarse prismatic structure parting to weak coarse and medium subangular blocky; soft, very friable; few fine pores; common fine concretions and segregations of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

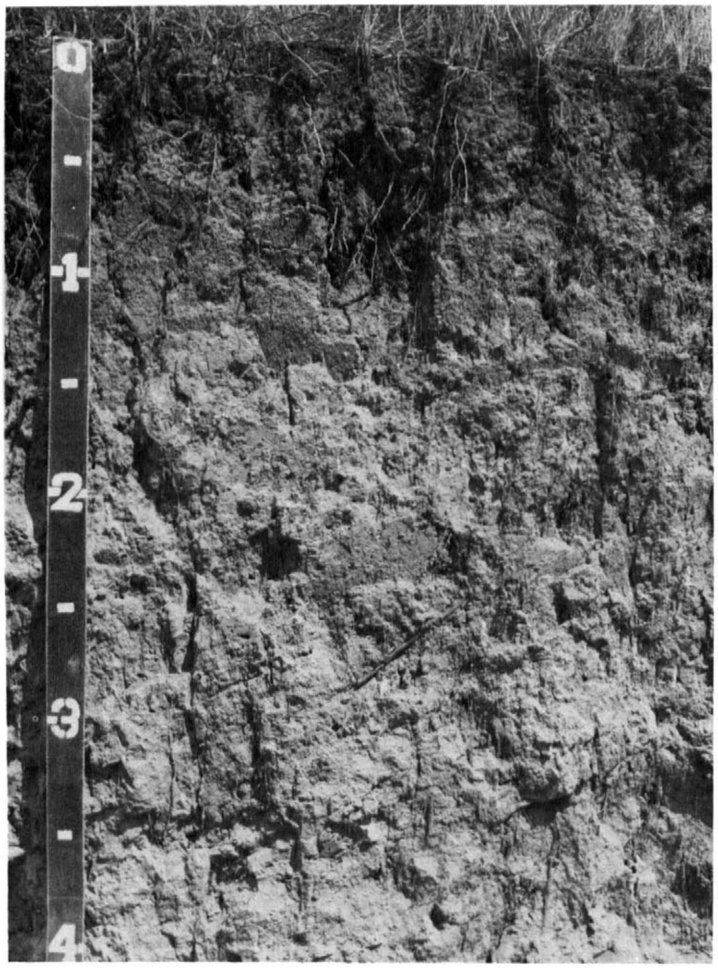

Figure 11.—**Profile of Nora silty clay loam, 6 to 10 percent slopes.**

C1ca—30 to 44 inches; light yellowish brown (2.5Y 6/3) silt loam, light olive brown (2.5Y 5/4) moist; few fine distinct gray (5Y 5/1) and yellowish brown (10YR 5/6) mottles, moist; weak very coarse and coarse subangular blocky structure; soft, very friable; common fine concretions and segregations of lime; strong effervescence; moderately alkailne; gradual wavy boundary.

C2—44 to 60 inches; light yellowish brown (2.5Y 6/3) silt loam, light olive brown (2.5Y 5/4) moist; few fine distinct gray (5Y 5/1) and yellowish brown (10YR 5/6) mottles, moist; massive; soft, very friable; few fine concretions and segregations of lime; strong effervescence; moderately alkaline.

Depth to lime ranges from 13 to 30 inches. The A horizon is very dark grayish brown or dark grayish brown silty clay loam or silt loam 4 to 8 inches thick. The B2 horizon is brown to light yellowish brown in a hue of 10YR or 2.5Y, and is silt loam or light silty clay loam. It is 9 to 17 inches thick. The B3 horizon commonly is calcareous, but the upper part is noncalcareous in some pedons. It is 6 to 12 inches thick.

Nora soils in mapping unit NeF have moist colors of very dark grayish brown or darker to a depth greater than that defined in the range for the series, but this difference does not alter their usefulness or behavior.

Nora soils are mapped with Crofton and Moody soils. They are deeper to lime than Crofton soils. Nora soils have a thinner B horizon and are shallower to lime than Moody soils.

NeF—Nora-Crofton silt loams, 20 to 50 percent slopes. These moderately steep to very steep soils are on upland breaks along the Big Sioux River and Brule Creek. The areas are mostly long and narrow and range to 80 acres in size.

This complex is about 50 percent Nora soil, 40 percent Crofton soil, and 10 percent other soils. The Nora soil is on the mid and lower parts of the landscape and is mostly moderately steep. The Crofton soil is on the higher parts of the landscape and is steep to very steep. The Nora soil has a surface layer of silt loam and, in most places, has a thicker surface layer than the Nora soil described as representative of the series.

Included with these soils in mapping are small areas of Alcester soils on foot slopes and along drainageways. Outcrops of glacial till and limestone are in some areas and are shown on the soil map by a special symbol.

Runoff is rapid, and the hazard of erosion is very severe. Controlling erosion is the main concern of management.

All areas remain in native vegetation and are used mainly for pasture. Deciduous trees and shrubs are in many areas, mainly on the Nora soil. Some trees are cut for posts, poles, and fuelwood and, in places, for saw logs. These soils are best suited to pasture, woodland, recreation, and wildlife habitat. Windbreak group 10; Nora soil in capability unit VIe–1 and pasture group F; Crofton soil in capability unit VIIe–1, not placed in a pasture group.

Omadi Series

The Omadi series consists of deep, well drained, nearly level, silty soils on high bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is grayish brown silt loam about 11 inches thick. The lower 3 inches is calcareous. Below that is calcareous, light brownish gray silt loam about 8 inches thick. The underlying material is calcareous silt loam that is mostly light gray and light brownish gray but has thin layers of dark grayish brown between depths of 22 and 28 inches.

Omadi soils have moderate organic-matter content and high fertility. Permeability is moderate, and the available water capacity is high.

Most areas are used for crops. A few areas are irrigated.

Representative profile of Omadi silt loam, in cultivation, 123 feet west and 2,460 feet north of the southeast corner of sec. 7, T. 90 N., R. 49 W.

Ap—0 to 8 inches; grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; slightly hard, friable, slightly sticky; neutral; abrupt smooth boundary.

A12—8 to 11 inches; grayish brown (10YR 5/2) silt loam, very dark grayish brown (10YR 3/2) moist; weak medium and fine subangular blocky structure; slightly hard, friable, slightly sticky; common fine pores; slight effervescence; mildly alkaline; common smooth boundary.

AC—11 to 19 inches; light brownish gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist; common fine distinct yellowish brown (10YR 5/4) mottles, moist, and few fine distinct strong brown (7.5YR 5/6) mottles, moist; weak medium and fine subangular blocky structure; slightly hard, friable; common fine pores; few very dark brown (10YR 2/2) channel fillings and worm casts, moist; strong effervescence; mildly alkaline; clear smooth boundary.

C1—19 to 22 inches; light gray (2.5Y 7/2) silt loam, grayish brown (2.5Y 5/2) moist; common fine distinct strong brown (7.5YR 5/6) and gray (5Y 5/1) mottles, moist; weak medium and fine subangular blocky structure; slightly hard, friable; few fine pores; few black (10YR 2/1) channel fillings and worm casts, moist; 1/2-inch thick

lens of very fine sandy loam at a depth of about 20 inches; strong effervescence; mildly alkaline; clear smooth boundary.

C2—22 to 28 inches; dark grayish brown (10YR 4/2) and light brownish gray (2.5Y 6/2) silt loam, very dark brown (10YR 2/2) and grayish brown (2.5Y 5/2) moist; few fine distinct strong brown (7.5YR 5/6) mottles, moist; weak fine subangular blocky structure; slightly hard, friable; common fine pores; common worm casts; slight effervescence; mildly alkaline; clear wavy boundary.

C3—28 to 48 inches; light brownish gray (2.5Y 6/2) silt loam, grayish brown (2.5Y 5/2) moist; many fine distinct strong brown (7.5YR 5/6) and gray (5Y 5/1) mottles, moist; massive, laminations evident; slightly hard, friable; common fine pores; strong effervescence; mildly alkaline; gradual smooth boundary.

C4—48 to 60 inches; light gray (2.5Y 7/2) silt loam, grayish brown (2.5Y 5/2) moist; common fine distinct strong brown (7.5YR 5/6) and gray (5Y 5/1) mottles, moist; massive, laminations evident; soft, very friable; strong effervescence; mildly alkaline.

Depth to lime commonly ranges from 5 to 10 inches, but lime is at the surface in some pedons. Between depths of 10 and 40 inches, the clay content is 18 to 28 percent, and fine and coarser sand is less than 15 percent. The A horizon ranges from grayish brown to dark gray silt loam or light silty clay loam 9 to 14 inches thick. Some pedons lack an AC horizon. Thin lenses of coarser or finer textured material and a buried A horizon are common in the C horizon. The C horizon is mildly alkaline or moderately alkaline.

Omadi soils are near Blencoe, Blyburg, Forney, Haynie, and Lakeport soils and are similar to Salix soils. Omadi soils are better drained and less clayey than Blencoe, Forney, and Lakeport soils. They contain more clay than Blyburg and Haynie soils and are shallower to lime than Salix soils.

Oa—Omadi silt loam. This is a nearly level soil on high bottom lands in areas that range to 400 acres in size. Slopes are 0 to 2 percent. They are long and plane and in places are broken by small, shallow swales or depressions. In most areas this soil has the profile described as representative of the series, but in some low areas it is moderately well drained and has a surface layer of silty clay.

Included with this soil in mapping are small areas of Blyburg soils on very slight rises that are slightly convex.

Runoff is slow, and the hazards of erosion and soil blowing are slight. This soil generally has few or no limitations for crops, but some areas are subject to flooding in some years. Maintaining fertility is the main concern of management.

Most areas are used for crops, and this soil is well suited to all crops commonly grown in the county. Corn and soybeans are the main crops. A few areas are irrigated. Capability unit I–1, pasture group F, windbreak group 3.

Onawa Series

The Onawa series consists of deep, somewhat poorly drained to poorly drained, level, clayey soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses, sedges, and deciduous trees.

In a representative profile the surface layer is calcareous, grayish brown silty clay about 7 inches thick. The underlying material to a depth of 25 inches is calcareous, light brownish gray and gray silty clay. Below this it is calcareous, light gray silt loam.

Onawa soils have moderately low organic-matter content and medium fertility. Permeability is slow to a depth of 25 inches and moderate below. The available water capacity is moderate or high. These soils have a seasonal water table at a depth of 2 to 4 feet and in places are subject to flooding.

Most areas are used for crops and some are irrigated. A few areas remain in native vegetation and are used for pasture.

Representative profile of Onawa silty clay, in cultivation, 2,270 feet north and 750 feet west of the southeast corner of sec. 25, T. 91 N., R. 50 W.

Ap—0 to 7 inches; grayish brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) moist; moderate fine granular structure; hard, firm, sticky and plastic; slight effervescence; mildly alkaline; abrupt smooth boundary.

C1g—7 to 25 inches; light brownish gray (2.5Y 6/2) and gray (5Y 5/1) silty clay, dark grayish brown (2.5Y 4/2), dark gray (5Y 4/1), and olive gray (5Y 4/2) moist; common medium distinct dark brown (7.5YR 4/4) mottles, moist, and few medium distinct black (5Y 2/1) mottles, moist; moderate fine subangular blocky structure; hard, very firm, sticky and plastic; slight effervescence; mildly alkaline; abrupt smooth boundary.

IIC2g—25 to 60 inches; light gray (2.5Y 7/2) silt loam, grayish brown (2.5Y 5/2) moist; common medium faint dark gray mottles, moist; many fine distinct dark brown (7.5YR 4/4) and strong brown (7.5YR 5/6) mottles, moist; and few fine distinct dark reddish brown (5YR 2/2) mottles, moist; massive, laminations evident; slightly hard, very friable; 1/2-inch thick layer of fine sand at a depth of about 36 inches; strong effervescence; mildly alkaline.

Thickness of clayey horizons over silty or loamy material ranges from 18 to 30 inches. Free carbonates commonly are throughout the profile, but in places the A horizon is noncalcareous. The A horizon ranges from grayish brown to dark gray in a hue of 2.5Y or 10YR and in places is silty clay loam. It is 6 to 10 inches thick. The C1 horizon averages 50 to 60 percent clay and in a few places is stratified with thin lenses of silt loam or very fine sandy loam. The IIC horizon is silt loam or very fine sandy loam and commonly is stratified with thin lenses of fine sand to silty clay.

Onawa soils are near Albaton, Grable, Haynie, and Percival soils and are similar to Blencoe soils. Onawa soils are less clayey in the lower part of the C horizon than Albaton soils. They have a thinner A horizon than Blencoe soils. Onawa soils are more poorly drained and more clayey than Grable and Haynie soils, and they have a less sandy IIC horizon than Percival soils.

Ob—Onawa silty clay. This is a level soil on wide bottom lands of large streams. Slopes are 0 to 1 percent. The areas are mostly broad flats, but some areas are narrow swales and partly filled former stream channels. In places the clayey layers overlying silt loam are more than 30 inches thick.

Included with this soil in mapping are small areas of Albaton and Percival soils. These soils are mostly in old channels and meander scars and make up as much as 20 percent of some mapped areas.

Runoff is slow. Farming commonly is delayed in spring because of wetness that results from the high water table, and the swales or meander scars commonly are flooded after heavy rain. This soil compacts and loses its tilth if farmed or grazed when wet. Overcoming wetness and maintaining tilth are the main concerns of management.

Most areas are used for corn and soybeans. This soil is better suited to corn and soybeans than to spring-sown small grain. Undrained areas in old stream channels are better suited to pasture and hay. Capability unit IIw–3 drained, IVw–2 undrained; pasture group A drained, B undrained; windbreak group 2.

Percival Series

The Percival series consists of deep, somewhat poorly drained, level, clayey soils on bottom lands. These soils formed in stratified alluvium. The native vegetation consisted mainly of tall grasses, sedges, and deciduous trees.

In a representative profile the surface layer is calcareous, grayish brown silty clay about 7 inches thick. The under-

lying material to a depth of 25 inches is calcareous, grayish brown and gray silty clay. Below this it is calcareous, light brownish gray, stratified fine sand and loamy fine sand.

Percival soils have moderately low organic-matter content and medium fertility. Permeability is slow in the clayey upper part of the profile and rapid in the sandy underlying material. The available water capacity is low. This soil has a seasonal water table at a depth of 1 to 3 feet, and some areas are subject to flooding.

Most areas are used for crops and some are irrigated. A few areas remain in native vegetation and are used for pasture.

Representative profile of Percival silty clay, in cultivation, 2,273 feet north and 90 feet west of the southeast corner of sec. 25, T. 91 N., R. 50 W.

Ap—0 to 7 inches; grayish brown (2.5Y 5/2) silty clay, very dark grayish brown (2.5Y 3/2) moist; weak fine subangular blocky structure; very hard, firm, sticky and plastic; slight effervescence; mildly alkaline; abrupt smooth boundary.

C1g—7 to 25 inches; grayish brown (2.5Y 5/2) and gray (5Y 5/1) silty clay, dark grayish brown (2.5Y 4/2) and dark gray (5Y 4/1) moist; common fine distinct strong brown (7.5YR 5/6) and dark brown (7.5YR 4/4) mottles, moist; moderate fine and very fine subangular blocky structure; extremely hard, very firm, sticky and plastic; slight effervescence; mildly alkaline; abrupt smooth boundary.

IIC2—25 to 60 inches; light brownish gray (2.5Y 6/2) stratified fine sand and loamy fine sand, grayish brown (2.5Y 5/2) moist; few fine distinct strong brown (7.5YR 5/6) mottles, moist; single grained; loose; slight effervescence; mildly alkaline.

Thickness of clayey horizons over sandy material ranges from 18 to 30 inches. Free carbonates commonly are throughout the profile, but in places the A horizon is noncalcareous. The A horizon ranges from grayish brown to dark gray in a hue of 2.5Y or 10YR. It is silty clay or silty clay loam less than 10 inches thick. The C1 horizon is silty clay or clay and in places is stratified with thin lenses of silt loam. It is mildly alkaline or moderately alkaline. In places the IIC horizon is stratified with thin lenses of fine textured material. The IIC horizon is mildly alkaline or moderately alkaline.

Percival soils are near Albaton, Blencoe, Forney, Grable, Haynie, and Onawa soils. Percival soils are more sandy in the lower part of the C horizon than Albaton, Blencoe, Forney, and Onawa soils. They are more poorly drained and more clayey than Grable and Haynie soils.

Pa—Percival silty clay. This is a level soil on bottom lands. Slopes are 0 to 1 percent. Some areas are on broad flats, and some are in narrow swales and partly filled former channels. The areas are mostly less than 60 acres in size. In places the depth to the underlying sandy alluvium is slightly more than 30 inches.

Included with this soil in mapping are small areas of Albaton, Onawa, and Sarpy soils. Albaton and Onawa soils are mostly in narrow swales or low areas, and Sarpy soils are on narrow humps. In places these soils make up as much as 20 percent of some mapped areas.

Runoff is slow. In some years farming is delayed because of wetness that results from a seasonal high water table or from flooding. The clayey surface layer compacts and loses its tilth if farmed when wet. The soil is droughty late in summer, however, because the underlying material is sand. Overcoming wetness and maintaining tilth are the main concerns of management.

Most areas are used for corn and soybeans. Small grain and alfalfa also are grown. If adequately drained, this soil is well suited to farming. Capability unit IIw-3, pasture group A, windbreak group 2.

Salix Series

The Salix series consists of deep, moderately well drained, nearly level, silty soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is silty clay loam about 17 inches thick. The upper part is dark gray, and the lower part is dark grayish brown. The subsoil is about 19 inches thick. It is brown silty clay loam in the upper part and calcareous, brown silt loam in the lower part. The underlying material is calcareous, brown silt loam to a depth of 54 inches. Below this it is calcareous, grayish brown silty clay loam.

Salix soils have high fertility and high organic-matter content. Permeability is moderate, and the available water capacity is high. These soils have a seasonal high water table at a depth of 3 to 5 feet, and some areas are subject to flooding.

Most areas are used for crops. A few areas are irrigated.

Representative profile of Salix silty clay loam, in cultivation, 132 feet west and 1,750 feet north of the southeast corner of sec. 24, T. 93 N., R. 49 W.

Ap—0 to 8 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak fine granular structure; slightly hard, friable; slightly acid; abrupt smooth boundary.

A3—8 to 17 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; weak very coarse prismatic structure parting to weak medium and fine subangular blocky; hard, friable, slightly sticky; common fine pores; slightly acid; clear wavy boundary.

B2—17 to 30 inches; brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; weak medium prismatic structure parting to moderate medium and fine subangular blocky; slightly hard, friable; common fine pores; slightly acid; gradual wavy boundary.

B2ca—30 to 36 inches; brown (10YR 5/3) silt loam, dark brown (10YR 4/3) moist; weak very coarse prismatic structure parting to weak coarse subangular blocky; slightly hard, friable; common fine pores; common fine segregations of lime; strong effervescence; mildly alkaline; gradual wavy boundary.

C1ca—36 to 54 inches; brown (10YR 5/3) silt loam, dark brown (10YR 4/3) moist; few fine distinct yellowish brown (10YR 5/6) mottles, moist; weak coarse subangular blocky structure; slightly hard, friable; many fine segregations of lime; strong effervescence; mildly alkaline; abrupt smooth boundary.

C2—54 to 60 inches; grayish brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; massive; hard, firm, slightly sticky and slightly plastic; strong effervescence; mildly alkaline.

Depth to lime ranges from 24 to 40 inches. The A horizon is silty clay loam or silt loam and ranges from 10 to 18 inches in thickness. The B2 horizon ranges from dark grayish brown to brown in a hue of 10YR or 2.5Y. It commonly is silty clay loam 10 to 14 inches thick, but in places it is silt loam. The B3 horizon is silty clay loam or silt loam 4 to 12 inches thick. The C horizon is silty clay loam or silt loam, and in places it is stratified with thin lenses of fine sand. In many places a buried A horizon is at a depth below 40 inches.

Salix soils are near Benclare, Blyburg, Davis, Forney, Kennebec, Luton, and Omadi soils. Salix soils are better drained and have a less clayey B horizon than Benclare soils. They are deeper to lime than Blyburg and Omadi soils. They are more silty and contain less sand than Davis soils. They are less clayey and better drained than Forney and Luton soils. Salix soils have a thinner A horizon and are shallower to lime than Kennebec soils.

Sa—Salix silty clay loam. This is a nearly level soil on high stream bottoms. Slopes are 0 to 2 percent. The areas are mostly long and narrow, but a few wide areas range to 200 acres in size.

Included with this soil in mapping are small areas of Benclare and Kennebec soils in swales and concave low areas.

Runoff is slow. Areas along the Big Sioux River are flooded in some years, but wetness generally is not a problem. This soil has only slight limitations for crops.

Most areas are used for crops, and a few areas are irrigated. Corn and soybeans are the main crops, but this soil is well suited to all crops grown in the county. Capability unit I–1, pasture group F, windbreak group 3.

Salmo Series

The Salmo series consists of deep, somewhat poorly drained, level, silty soils that are high in salt content. These soils are on bottom lands. They formed in alluvium. The native vegetation consisted mainly of tall grasses, sedges, and a few deciduous trees.

In a representative profile the surface layer is calcareous, dark gray silty clay loam and silt loam about 15 inches thick. Spots and streaks of gypsum and other salts are in the surface layer and extend into the underlying material. The underlying material, to a depth of 46 inches, is calcareous silt loam that is dark gray in the upper part, grayish brown in the middle, and gray in the lower part. Calcareous, gray silty clay loam is at a depth of 46 inches.

Salmo soils have high organic-matter content and medium fertility. Permeability is moderately slow, and the available water capacity is high. These soils are subject to flooding and have a seasonal high water table at a depth of 2 or 3 feet.

Most areas are used for crops. A few areas remain in native vegetation and are used for pasture and hay.

Representative profile of Salmo silty clay loam, somewhat poorly drained, in cultivation, 240 feet north and 925 feet east of the southwest corner of sec. 21, T. 92 N., R. 50 W.

Apsa—0 to 8 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak fine subangular blocky structure; hard, friable, slightly sticky; common fine segregations of salt; few nests and crystals of gypsum; strong effervescence; moderately alkaline; abrupt smooth boundary.

A12cssa—8 to 15 inches; dark gray (5Y 4/1) silt loam, black (5Y 2/1) moist; many fine distinct brown (7.5YR 4/2) mottles, moist; weak coarse and medium subangular blocky structure; slightly hard, very friable; common fine segregations of salt; many nests and crystals of gypsum; strong effervescence; moderately alkaline; gradual wavy boundary.

C1gcs—15 to 26 inches; dark gray (5Y 4/1) silt loam, very dark gray (5Y 3/1) moist; many fine distinct brown (7.5YR 4/2) mottles, moist, and common fine prominent strong brown (7.5YR 5/6) mottles, moist; weak coarse and medium subangular blocky structure; slightly hard, very friable; many nests and crystals of gypsum; strong effervescence; moderately alkaline; gradual wavy boundary.

C2gcs—26 to 33 inches; grayish brown (2.5Y 5/2) silt loam, very dark grayish brown (2.5Y 3/2) moist; many fine prominent strong brown (7.5YR 5/6) mottles, moist; common fine distinct very dark brown (10YR 2/2) mottles, moist; and many fine prominent light olive brown (2.5Y 5/6) mottles, moist; weak coarse subangular blocky structure; slightly hard, friable, slightly sticky; many nests and crystals of gypsum; slight effervescence; moderately alkaline; gradual wavy boundary.

C3g—33 to 46 inches; gray (5Y 6/1) silt loam, gray (5Y 5/1) moist; many medium and coarse prominent yellowish brown (10YR 5/6) mottles, moist; massive; hard, friable, slightly sticky and slightly plastic; few nests and crystals of gypsum; few fine and medium segregations of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C4g—46 to 60 inches; gray (5Y 6/1 and 5/1) silty clay loam, gray (5Y 5/1) and dark gray (5Y 4/1) moist; many fine, medium, and coarse prominent yellowish brown (10YR 5/6) mottles, moist, and few fine distinct dark reddish brown (5YR 2/2) mottles, moist; massive; hard, firm, sticky and plastic; many fine and medium segregations of lime; strong effervescence; moderately alkaline.

The greatest accumulation of salts other than gypsum is in the A horizon. Electrical conductivity of the saturation extract ranges from 4 to 16 millimhos per centimeter in the upper 15 inches and from 4 to 8 below this. The A horizon is dark gray or very dark gray in a hue of 10YR, 2.5Y, or 5Y, or it is neutral. It ranges from 11 to 20 inches in thickness. The C horizon ranges from dark gray to light olive gray in a hue of 5Y or 2.5Y, or it is neutral. In places the C horizon below a depth of 40 inches is thinly stratified with lenses of fine sand or silty clay.

Salmo soils are near Blencoe, Blyburg, James, Luton, Omadi, and Salix soils. Salmo soils contain more salts than Blencoe, Blyburg, Luton, Omadi, and Salix soils. They contain less clay than James soils.

Sb—Salmo silty clay loam, somewhat poorly drained. This is a level soil on bottom lands. Slopes are 0 to 1 percent. The areas are long and narrow and range from 10 to 100 acres in size.

Included with this soil in mapping are small areas of James soils on the lower parts of the landscape.

Runoff is slow. Wetness from flooding and from the high water table delays planting in some years. Crop growth is affected by the high content of salts. Overcoming salinity and wetness are the main concerns of management.

Most areas are used for crops. This soil is better suited to late-planted crops such as corn, soybeans, or sorghum than to spring-sown small grain. Capability unit IIIw-3, pasture group J, windbreak group 10.

Sarpy Series

The Sarpy series consists of deep, excessively drained, level to undulating, sandy soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses and deciduous trees.

In a representative profile the surface layer is calcareous, grayish brown loamy fine sand about 4 inches thick. The upper 4 inches of the underlying material is calcareous, pale brown fine sand. Below this it is calcareous, light gray, stratified loamy fine sand and fine sand.

Sarpy soils have low fertility and low organic-matter content. Permeability is rapid, and the available water capacity is low. Some areas are subject to flooding.

Most of the level and nearly level areas are used for crops. A few areas are irrigated. Most of the gently undulating to undulating areas remain in native vegetation and are used for pasture, recreation, or wildlife habitat.

Representative profile of Sarpy loamy fine sand, 3 to 9 percent slopes, in pasture, 290 feet east and 760 feet north of the southwest corner of sec. 31, T. 90 N., R. 48 W.

A1—0 to 4 inches; grayish brown (10YR 5/2) loamy fine sand, dark grayish brown (10YR 4/2) moist; weak fine granular structure; soft, very friable; slight effervescence; mildly alkaline; clear smooth boundary.

C1—4 to 8 inches; pale brown (10YR 6/3) fine sand, dark grayish brown (10YR 4/2) moist; single grained; loose; slight effervescence; mildly alkaline; clear smooth boundary.

C2—8 to 60 inches; light gray (10YR 7/2) stratified loamy fine sand and fine sand, grayish brown (10YR 5/2) moist; single grained; loose; thin lens of silt loam at a depth of about 48 inches; slight effervescence; mildly alkaline.

The A horizon ranges from dark grayish brown to pale brown. It commonly ranges from fine sandy loam to sand, but some pedons have an overwash of silty clay, silty clay loam, silt loam, or very fine sandy loam. The C horizon commonly has thin lenses of silt loam, silty clay loam, or silty clay, but the texture between depths

of 10 and 40 inches averages loamy fine sand or fine sand. The C horizon is mildly alkaline or moderately alkaline.

Sarpy soils are more sandy between depths of 10 and 40 inches than the nearby Albaton, Grable, Haynie, Onawa, and Percival soils.

ScB—Sarpy loamy fine sand, 3 to 9 percent slopes. This gently undulating to undulating soil is on bottom lands along the Missouri River. Slopes are short and hummocky. In most areas this soil has the profile described as representative of the series, but in places where soil blowing is common the surface layer is sand or fine sand, and in some low areas between the hummocks the surface layer is silty clay.

Included with this soil in mapping are small areas of Percival soils in low areas between the hummocks or mounds.

Runoff is slow. This soil is droughty, and the hazard of soil blowing is very severe. Controlling soil blowing and conserving moisture are the main concerns of management.

Most areas remain in native vegetation and are used for pasture. Little or no vegetation grows in severely eroded areas (fig. 12). Capability unit VIs-1, pasture group H, windbreak group 7.

SdA—Sarpy silty clay overwash, 0 to 1 percent slopes. This level soil is on bottom lands along the Missouri River. Some areas are broad, and some are narrow swales or partly filled former stream channels. This soil has a silty clay overwash 4 to 12 inches thick. In some areas of slightly elevated humps the surface layer is silt loam or very fine sandy loam.

Included with this soil in mapping are small areas of Percival soils on low parts of the landscape.

Runoff is slow, and in places this soil has a seasonal high water table at a depth of 2 to 4 feet. Wetness that results from flooding or from a seasonal high water table delays planting in some years, but the soil is droughty late in summer because the underlying material is sand. This soil compacts and loses its tilth if farmed when wet. Conserving moisture and maintaining tilth are the main concerns of management.

Many areas are used for crops. A few areas remain in native vegetation and are used for pasture. Unless irrigated, this soil is better suited to small grain and tame grasses than to row crops. Capability unit IVs-1, pasture group H, windbreak group 7.

***Figure 12.*—An eroded area of Sarpy loamy fine sand, 3 to 9 percent slopes.**

SeA—Sarpy soils, 0 to 3 percent slopes. These nearly level soils are on bottom lands along the Missouri River. The areas consist of many slight rises that are broken by intervening low spots. The surface layer ranges from fine sand to silt loam on the convex rises and is silty clay or silty clay loam in the low spots.

Included with these soils in mapping are areas of Grable and Percival soils. Grable soils are on convex rises and Percival soils are in small, low areas.

Runoff is slow, and in places there is a seasonal high water table. These soils are droughty late in summer because of the underlying sand, and the hazard of soil blowing is severe. Controlling soil blowing, conserving moisture, and improving fertility are the main concerns of management.

Most areas are used for crops. A few areas remain in native vegetation and are used for pasture. Unless irrigated, these soils are best suited to small grain and tame grasses. Capability unit IVs-1, pasture group H, windbreak group 7.

Shindler Series

The Shindler series consists of deep, well drained, gently undulating to steep, loamy soils on uplands. These soils formed in glacial till. The native vegetation consisted mainly of mid and tall grasses, but deciduous trees and shrubs grew in some areas.

In a representative profile the surface layer is dark gray clay loam about 8 inches thick. The subsoil is calcareous, dark gray and grayish brown clay loam about 10 inches thick. The underlying material is calcareous, light yellowish brown clay loam.

Shindler soils have moderate organic-matter content and medium fertility. Permeability is moderate in the subsoil and moderately slow in the underlying material. The available water capacity is high.

Most of the gently undulating areas are used for crops. Most of the rolling to steep areas are in native vegetation and are used for pasture.

Representative profile of Shindler clay loam, 9 to 15 percent slopes, in pasture, 210 feet north and 2,550 feet west of the southeast corner of sec. 19, T. 95 N., R. 48 W.

A1—0 to 8 inches; dark gray (10YR 4/1) clay loam, black (10YR 2/1) moist; weak fine subangular blocky structure; slightly hard, friable, slightly sticky; neutral; clear smooth boundary.

B2—8 to 13 inches; dark gray (10YR 4/1) and grayish brown (2.5Y 5/2) clay loam, black (10YR 2/1) and very dark grayish brown (2.5Y 3/2) moist; weak medium prismatic structure parting to moderate medium and fine subangular blocky; hard, friable, slightly sticky and slightly plastic; many worm casts; slight effervescence; mildly alkaline; clear wavy boundary.

B3ca—13 to 18 inches; grayish brown (2.5Y 5/2) and dark gray (10YR 4/1) clay loam, very dark grayish brown (2.5Y 3/2) and black (10YR 2/1) moist; weak medium prismatic structure parting to moderate medium and fine subangular blocky; hard, firm, slightly sticky and slightly plastic; few fine segregations of lime; strong effervescence; mildly alkaline; clear wavy boundary.

C1ca—18 to 33 inches; light yellowish brown (2.5Y 6/3) clay loam, light olive brown (2.5Y 5/3) moist; common medium distinct gray (5Y 5/1) mottles, moist, and common medium and coarse distinct yellowish brown (10YR 5/6)

and strong brown (7.5YR 5/6) mottles, moist; weak coarse subangular blocky structure parting to weak medium and fine subangular blocky; hard, firm, slightly sticky and slightly plastic; common medium segregations of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C2—33 to 60 inches; light yellowish brown (2.5Y 6/3) clay loam, light olive brown (2.5Y 5/3) moist; common medium and coarse distinct yellowish brown (10YR 5/6), strong brown (7.5YR 5/6), and gray (5Y 5/1) mottles, moist; massive; hard, firm, slightly sticky and plastic; few medium segregations of lime; strong effervescence; moderately alkaline.

Depth to free carbonates commonly ranges from 6 to 8 inches, but in some cultivated areas carbonates are at the surface. The A horizon ranges from very dark gray to dark grayish brown clay loam or heavy loam 6 to 8 inches thick. The B2 horizon ranges from dark gray to light olive brown in a hue of 10YR or 2.5Y. It is 4 to 6 inches thick. The B3ca horizon is 5 to 10 inches thick. The C horizon has small pockets of sand in places below a depth of 40 inches. It is mildly alkaline or moderately alkaline.

Shindler soils are mapped with Egan soils and are near Alcester, Crofton, Davis, and Wentworth soils. Shindler soils contain less silt, have a thinner B horizon, and are shallower to lime than Alcester, Egan, and Wentworth soils. Shindler soils are less silty than Crofton soils, and are better drained and shallower to lime than Davis soils.

ShD—Shindler clay loam, 9 to 15 percent slopes. This soil is on the sides of drainageways or on the breaks and sides of valleys of major streams. The areas are mostly narrow and are less than 40 acres in size. Slopes are convex and mostly rolling, but in some places they are less than 9 percent in gradient. This soil has a profile similar to the one described as representative of the series, but in places lime is at a greater depth and in other places the surface layer is thinner.

Included with this soil in mapping are small areas of Crofton, Davis, and Egan soils. Crofton soils are on the highest positions on well-rounded ridges and knolls. Davis soils are on foot slopes and along drainageways. Egan soils are below the Shindler soil, mostly west of Brule Creek. Small gravelly spots in some areas are shown on the soil map by a special symbol.

Runoff is medium, and the hazard of erosion is very severe. Controlling erosion is the main concern of management.

Some areas are used for crops, but this soil is better suited to pasture or hay. Capability unit VIe-3, pasture group G, windbreak group 10.

ShE—Shindler clay loam, 15 to 30 percent slopes. This soil is on the sides of valleys of large streams and on the short side slopes of deeply entrenched drainageways. The areas are mostly less than 40 acres in size. Slopes are short, convex, and mostly hilly, but some are steep. In places the surface layer is thinner than that of the soil described as representative of the series, and in places lime is nearer the surface.

Included with this soil in mapping are small areas of Crofton and Davis soils. Crofton soils are in the highest places on well-rounded ridges, and Davis soils are on foot slopes along drainageways. Small gravelly spots in some areas are shown on the soil map by a special symbol.

Runoff is medium to rapid, and the hazard of erosion is very severe. Controlling erosion is the main concern of management.

Most areas are in native vegetation, and a few are in tame grasses. A few clumps of native trees are in some areas. This soil is better suited to pasture than to other uses. Capability unit VIe-3, pasture group G, windbreak group 10.

Storla Series

The Storla series consists of calcareous, somewhat poorly drained, nearly level, loamy soils that are moderately deep over gravelly sand. These soils are on bottom lands. They formed in alluvium overlying outwash sand and gravel. The native vegetation consisted mainly of tall grasses and sedges.

In a representative profile the surface layer is calcareous, very dark gray loam about 10 inches thick. Below that is calcareous, very dark gray and olive brown loam about 4 inches thick. The underlying material to a depth of 31 inches is calcareous, light yellowish brown and grayish brown loam. Below this it is calcareous, light yellowish brown and yellowish brown loamy sand and gravelly sand.

Storla soils have high organic-matter content and medium fertility. Permeability is moderate in the loamy upper part of the profile, and rapid in the sandy underlying material. The available water capacity is low or moderate. These soils have a seasonal high water table at a depth of 2 or 3 feet.

Most areas are used for crops. A few areas are in tame or native grasses and are used for pasture and hay.

Representative profile of Storla loam, in cultivation, 380 feet west and 2,225 feet north of the southeast corner of sec. 35, T. 95 N., R. 50 W.

Ap—0 to 6 inches; very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak fine subangular blocky structure; slightly hard, friable; slight effervescence; moderately alkaline; abrupt smooth boundary.

A12—6 to 10 inches; very dark gray (10YR 3/1) loam, black (10YR 2/1) moist; weak medium and fine subangular blocky structure; slightly hard, friable; slight effervescence; moderately alkaline; clear wavy boundary.

ACca—10 to 14 inches; very dark gray (10YR 3/1) and olive brown (2.5Y 4/3) loam, black (10YR 2/1) and very dark grayish brown (2.5Y 3/3) moist; weak coarse subangular blocky structure parting to weak medium and fine subangular blocky; slightly hard, friable; many fine pores; common fine segregations of lime; strong effervescence; moderately alkaline; clear wavy boundary.

C1ca—14 to 22 inches; light yellowish brown (2.5Y 6/3) and grayish brown (2.5Y 5/2) loam, light olive brown (2.5Y 5/3) and dark grayish brown (2.5Y 4/2) moist; few fine distinct yellowish brown (10YR 5/6) mottles, moist; weak coarse subangular blocky structure parting to weak fine subangular blocky; slightly hard, friable, slightly sticky; many fine pores; common worm casts; many fine and medium segregations of lime; violent effervescence; moderately alkaline; gradual wavy boundary.

C2ca—22 to 31 inches; light yellowish brown (2.5Y 6/3) loam, light olive brown (2.5Y 5/4) moist; common fine distinct yellowish brown (10YR 5/6) and very dark brown (10YR 2/2) mottles, moist; weak coarse subangular blocky structure; slightly hard, friable; few pebbles; few fine dark concretions of iron and manganese oxides; few fine segregations of gypsum; many medium segregations of lime; violent effervescence; moderately alkaline; clear wavy boundary.

IIC3—31 to 36 inches; light yellowish brown (2.5Y 6/3) and yellowish brown (10YR 5/4) loamy sand, light olive brown (2.5Y 5/4) and dark yellowish brown (10YR 4/4) moist; many fine distinct strong brown (2.5YR 5/6) and very dark brown (10YR 2/2) mottles, moist; single grained; loose; common fine dark concretions of iron and manganese oxides; few medium segregations of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

IIC4—36 to 60 inches; light yellowish brown (2.5Y 6/3) and yellowish brown (10YR 5/4) gravelly sand, light olive brown (2.5Y 5/4) and dark yellowish brown (10YR 4/4) moist; single grained; loose; common fine dark concretions of iron and manganese oxides; strong effervescence; moderately alkaline.

Depth to sand, gravelly sand, or sand and gravel ranges from 20 to 40 inches. The calcium carbonate equivalent ranges from

about 3 to 10 percent in the A horizon and from about 16 to 30 percent in the Cca horizon. The A horizon is very dark gray or dark gray in a hue of 10YR or 2.5Y. It is 6 to 10 inches thick. Reaction in all horizons is mildly alkaline or moderately alkaline. Some pedons lack an ACca horizon. Segregations of gypsum and lime range from few to many in the Cca horizon. The IIC horizon ranges from loamy sand to gravel.

Storla soils are near Calco, Dempster, Enet, and Graceville soils. Storla soils are better drained and have a more sandy C horizon than Calco soils. They are more poorly drained and more calcareous than Dempster, Enet, and Graceville soils.

St—Storla loam. This is a nearly level soil on high stream bottoms. The areas are long and narrow and range to 160 acres in size. Slopes are 0 to 2 percent. In most areas this soil has the profile described as representative of the series, but in places the surface layer is more than 10 inches thick, and the depth to sand and gravel is more than 40 inches, or the surface layer is silty clay loam.

Included with this soil in mapping are small areas of Calco soils in swales and low spots.

Runoff is slow. Wetness resulting from the high water table delays planting in some years, but this soil is droughty late in summer because the underlying material is gravelly sand. The high content of lime affects the growth of crops. Conserving moisture and improving fertility are the main concerns of management.

Most areas are used for corn, soybeans, oats, and alfalfa. Unless irrigated, this soil is better suited to spring-sown small grain and tame grasses than to row crops. Capability unit IIIs-4, pasture group D, windbreak group 1.

Thurman Series

The Thurman series consists of deep, somewhat excessively drained, gently undulating to undulating, loamy soils on uplands and terrace fronts. These soils formed in sandy materials that have been reworked by wind. The native vegetation consisted mainly of tall and mid grasses.

In a representative profile the surface layer is grayish brown and dark grayish brown fine sandy loam about 10 inches thick. Below that is brown loamy fine sand about 7 inches thick. The underlying material to a depth of 41 inches is yellowish brown loamy fine sand. Below this it is calcareous, pale brown loamy fine sand and fine sandy loam.

Thurman soils have moderately low organic-matter content and medium fertility. Permeability is rapid, and the available water capacity is low to moderate.

Most areas are used for crops. A few areas are in native or tame grasses and are used for pasture.

Representative profile of Thurman fine sandy loam, 3 to 9 percent slopes, in cultivation, 115 feet east and 1,700 feet south of the northwest corner of sec. 1, T. 94 N., R. 50 W.

Ap—0 to 6 inches; grayish brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak fine granular structure; soft, very friable; slightly acid; abrupt smooth boundary.

A12—6 to 10 inches; dark grayish brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) moist; weak medium subangular blocky structure; soft, very friable; slightly acid; clear wavy boundary.

AC—10 to 17 inches; brown (10YR 5/3) loamy fine sand, dark brown (10YR 3/3) moist; few tongues of very dark grayish brown (10YR 3/2) moist; weak coarse prismatic structure; loose; neutral; clear wavy boundary.

C1—17 to 41 inches; yellowish brown (10YR 5/4) loamy fine sand, dark yellowish brown (10YR 4/4) moist; few very dark grayish brown (10YR 3/2) worm channels, moist; weak coarse subangular blocky structure parting to single grained; loose; neutral; clear wavy boundary.

C2ca—41 to 50 inches; pale brown (10YR 6/3) loamy fine sand, yellowish brown (10YR 5/4) moist; single grained; loose; few fine concretions and segregations of lime; strong effervescence; mildly alkaline; gradual wavy boundary.

C3ca—50 to 60 inches; pale brown (10YR 6/3) fine sandy loam, yellowish brown (10YR 5/4) moist; massive; slightly hard, friable; few fine concretions and segregations of lime; strong effervescence; mildly alkaline.

Depth to lime ranges from 30 to 60 inches or more. The A horizon is dark gray to grayish brown fine sandy loam, loamy fine sand, or loam. It is 10 to 15 inches thick. Some pedons lack an AC horizon. The C horizon to a depth of 40 inches is loamy fine sand or fine sand, but below 40 inches it ranges from sand to silt loam.

Thurman soils are more sandy in horizons immediately below a depth of 10 inches than nearby Crofton, Dempster, Enet, Moody, and Nora soils. They contain less gravel in the C horizon than Dempster and Enet soils.

TaB—Thurman fine sandy loam, 3 to 9 percent slopes. This gently undulating to undulating soil is in irregularly shaped areas that range from 5 to 200 acres in size. Slopes are mostly less than 9 percent, but in some areas they range to 12 percent. In most places this soil has the profile described as representative of the series, but in a few places it is calcareous at a depth of less than 30 inches.

Included with this soil in mapping are small areas of Crofton, Moody, and Nora soils in places where the sandy material is absent. Crofton soils are on the higher parts of the landscape. Moody and Nora soils generally are on the lower parts of the landscape where slopes are concave.

Runoff is slow. This soil is somewhat droughty, and the hazard of soil blowing is very severe. Controlling soil blowing and conserving moisture are the main concerns of management.

Most areas are used for crops. This soil is better suited to pasture and hay than to crops because of the soil blowing hazard. Capability unit IVe-3, pasture group H, windbreak group 5.

Wakonda Series

The Wakonda series consists of deep, moderately well drained, nearly level, calcareous, silty soils on uplands. These soils formed in silty glacial drift. The native vegetation consisted mainly of tall grasses.

In a representative profile the surface layer is calcareous, grayish brown silt loam about 10 inches thick. The underlying material is calcareous, light yellowish brown silt loam.

Wakonda soils have high organic-matter content and medium fertility. Permeability is moderate, and the available water capacity is high. These soils have a seasonal high water table at a depth of 2 to 5 feet.

Most areas are used for crops. A few areas are used for pasture.

Representative profile of Wakonda silt loam, in an area of Wakonda-Worthing-Chancellor complex, in cultivation, 2,580 feet south and 310 feet east of the northwest corner of sec. 3, T. 92 N., R. 50 W.

Ap—0 to 6 inches; grayish brown (10YR 5/2) silt loam, very dark brown (10YR 2/2) moist; weak medium and fine subangular blocky structure; slightly hard, friable; few olive brown (2.5Y 4/3) worm casts, moist; few pebbles and visible sand grains; strong effervescence; mildly alkaline; abrupt smooth boundary.

A12—6 to 10 inches; grayish brown (10YR 5/2) silt loam, very dark brown (10YR 2/2) moist; weak coarse and medium subangular blocky structure; slightly hard, friable; few olive brown (2.5Y 4/3) worm casts, moist; few pebbles and visible sand grains; strong effervescence; mildly alkaline; clear smooth boundary.

C1ca—10 to 17 inches; light yellowish brown (2.5Y 6/3) silt loam, olive brown (2.5Y 4/3) moist; weak coarse subangular blocky structure; slightly hard, friable; common very dark brown (10YR 2/2) worm casts, moist; many fine segregations of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C2ca—17 to 31 inches; light yellowish brown (2.5Y 6/3) silt loam, olive brown (2.5Y 4/3) moist; few fine distinct yellowish brown (10YR 5/6) mottles, moist, and few fine faint olive gray mottles, moist; weak coarse subangular blocky structure; slightly hard, friable; few fine segregations of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C3cacs—31 to 45 inches; light yellowish brown (2.5Y 6/3) silt loam, olive brown (2.5Y 4/3) moist; many fine distinct strong brown (7.5YR 5/6), light gray (5Y 6/1), and dark reddish brown (5YR 2/2) mottles, moist; weak coarse subangular blocky structure; hard, friable; common fine dark concretions of iron and manganese oxides; many medium segregations of gypsum; few medium segregations of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C4g—45 to 60 inches; light yellowish brown (2.5Y 6/3) silt loam, olive brown (2.5Y 4/3) moist; many medium and coarse distinct light gray (5Y 6/1) mottles, moist, and many fine and medium distinct strong brown (7.5YR 5/6) mottles, moist; massive; hard, friable; few fine dark concretions of iron and manganese oxides; few medium segregations of gypsum; few fine concretions of lime; strong effervescence; mildly alkaline.

Electrical conductivity of the saturation extract ranges from 2 to 4 millimhos per centimeter in the A horizon and from 4 to 8 in the C horizon. The calcium carbonate equivalent ranges from 3 to 10 percent in the A horizon and from 16 to 30 percent in the Cca horizon. Reaction in all horizons is mildly alkaline or moderately alkaline. The A horizon is dark gray to grayish brown silt loam or silty clay loam 7 to 12 inches thick. In places visible salts other than gypsum are in the lower part of the C horizon. In places the C horizon below a depth of 40 inches is clay loam or loam.

Wakonda soils are mapped with Chancellor and Worthing soils and are near Egan and Wentworth soils. Wakonda soils are more calcareous than all of these soils. They contain less clay than Chancellor and Worthing soils and are more poorly drained than Egan and Wentworth soils.

Wa—Wakonda-Worthing-Chancellor complex. This complex is about 45 percent Wakonda silt loam, 30 percent Worthing silty clay loam, 20 percent Chancellor silty clay loam, and 5 percent other soils. The areas are as large as 1,500 acres in size and consist of broad flats that contain many circular depressions and shallow swales between slightly convex rises. Slopes are 0 to 3 percent. The Wakonda soil is on rises and in places has a surface layer of loam. The Worthing soil is in depressions, and the Chancellor soil is in shallow swales that commonly connect the depressions. In places the Chancellor soil has a less clayey subsoil than is described as representative of the Chancellor series.

Included with these soils in mapping are small areas of Wentworth soils on the higher parts of slight rises.

Runoff is slow and ponds on the Worthing soil. Wetness commonly delays farming, especially on the Worthing soil. If farmed when wet, the Chancellor and Worthing soils compact and lose their tilth. The calcareous Wakonda soil is subject to soil blowing, and its high content of lime affects crop growth. Overcoming wetness, maintaining tilth, and controlling soil blowing are the major concerns of management.

If adequately drained, these soils are suited to all crops commonly grown in the county. They are better suited to corn, soybeans, sorghum, or other late-planted crops than to spring-sown small grain. If not adequately drained, the Worthing soil is best suited to pasture and hay. Wakonda soil in capability unit IIe-4, pasture group F, windbreak group 1; Worthing soil in capability unit IIIw-1 drained and Vw-2 undrained, pasture group A drained and B undrained, windbreak group 10; Chancellor soil in capability unit IIw-1, pasture group A, windbreak group 2.

Wentworth Series

The Wentworth series consists of deep, well drained, nearly level to gently sloping, silty soils on uplands. These soils formed in silty glacial drift. The native vegetation consisted mainly of mid and tall grasses.

In a representative profile the surface layer is dark grayish brown silty clay loam about 9 inches thick. The subsoil is silty clay loam about 27 inches thick. It is grayish brown in the upper part, brown in the middle, and grayish brown in the lower part. The lower part of the subsoil is calcareous and has spots and streaks of soft lime that extend into the underlying material. The underlying material is calcareous, light olive brown silty clay loam to a depth of 50 inches. Below this it is stratified light olive brown loam and silt loam.

Wentworth soils have high fertility and high organic-matter content. Permeability is moderate, and the available water capacity is high.

Most areas are used for crops. A few areas are used for pasture.

Representative profile of Wentworth silty clay loam, 0 to 2 percent slopes, in cultivation, 100 feet east and 1,960 feet north of the southwest corner of sec. 18, T. 95 N., R. 50 W.

Ap—0 to 6 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; weak fine granular structure; slightly hard, friable, slightly sticky; slightly acid; abrupt smooth boundary.

A12—6 to 9 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; weak medium subangular blocky structure parting to weak fine granular; slightly hard, friable, slightly sticky; slightly acid; clear smooth boundary.

B21—9 to 14 inches; grayish brown (10YR 5/2) silty clay loam, dark grayish brown (10YR 4/2) moist; weak coarse and medium prismatic structure parting to weak medium subangular blocky; hard, friable, slightly sticky; few fine pores; few very dark brown (10YR 2/2) root channel fillings and worm casts, moist; slightly acid; clear wavy boundary.

B22—14 to 27 inches; brown (10YR 5/3) silty clay loam, dark brown (10YR 4/3) moist; weak coarse and medium prismatic structure parting to weak medium subangular blocky; hard, friable, slightly sticky; few fine pores; slightly acid; clear wavy boundary.

B3ca—27 to 36 inches; grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; common medium faint dark gray mottles, moist, and few fine distinct yellowish brown (10YR 5/6) mottles, moist; weak coarse prismatic structure parting to weak coarse and medium subangular blocky; hard, friable, slightly sticky; few fine pores; common fine and medium segregations of lime; strong effervescence; neutral; gradual wavy boundary.

C1ca—36 to 50 inches; light olive brown (2.5Y 5/3) silty clay loam, olive brown (2.5Y 4/3) moist; many medium faint olive gray mottles, moist, and many fine and medium distinct yellowish brown (10YR 5/6) mottles, moist; weak coarse and medium subangular blocky structure; hard, friable, slightly sticky; 1-inch thick layer of loam at a depth of 38 inches; few fine dark concretions of iron and manganese oxides; common fine and medium segregations of lime; strong effervescence; mildly alkaline; clear wavy boundary.

C2—50 to 60 inches; light olive brown (2.5Y 5/3) stratified loam and silt loam, olive brown (2.5Y 4/3) moist; many medium faint olive gray mottles, moist, and many fine and medium distinct yellowish brown (10YR 5/6) mottles, moist; massive, few horizontal cleavage planes evident; hard, friable, slightly sticky; 1-inch thick layer of sandy

loam at a depth of 50 inches; common fine dark concretions of iron and manganese oxides; common fine segregations of lime; strong effervescence; mildly alkaline.

Depth to free carbonates ranges from 18 to 32 inches. The A horizon ranges from very dark gray to dark grayish brown. It is slightly acid or neutral and is 6 to 10 inches thick. The B2 horizon has colors in a hue of 10YR or 2.5Y that range from dark grayish brown to light olive brown in the upper part and from brown to light yellowish brown in the lower part. It is 12 to 22 inches thick. The B3ca horizon is 6 to 10 inches thick. The C horizon is silty clay loam or silt loam and commonly is stratified with thin layers of loam, very fine sandy loam, or sandy loam. It is mildly alkaline or moderately alkaline. In places clay loam or loam glacial till is at a depth of 40 to 60 inches.

Wentworth soils are mapped with or are near Chancellor, Egan, and Worthing soils and are similar to Moody and Nora soils. Wentworth soils are better drained and have a less clayey B horizon than Chancellor and Worthing soils. They have deeper silty horizons than Egan soils. Unlike Moody and Nora soils, Wentworth soils have a silty C horizon that is thinly stratified with loamy material.

WbA—Wentworth silty clay loam, 0 to 2 percent slopes. This is a nearly level soil on uplands in irregularly shaped areas that are mostly less than 150 acres in size. Slopes are long and smooth. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Egan and Worthing soils. Egan soils are on very slight rises. Worthing soils are in small depressions less than 2 acres in size that are shown on the soil map by a wet spot symbol.

Runoff is slow, and the hazard of erosion is slight. This soil has few or no limitations for crops. Maintaining fertility is the main concern of management.

Almost all areas are used for crops. Corn, oats, soybeans, and alfalfa are the main crops. This soil is well suited to all crops grown in the county. Capability unit I–2, pasture group F, windbreak group 3.

WbB—Wentworth silty clay loam, 2 to 6 percent slopes. This is a gently sloping soil on uplands on the sides of ridges and shallow drainageways. The areas are mostly long and narrow and range from 5 to 200 acres in size. Slopes are plane to slightly convex.

Included with this soil in mapping are small areas of Egan and Shindler soils. Egan soils are intermingled with the Wentworth soil, and Shindler soils are on the higher parts of the landscape where slopes are more convex.

Runoff is medium, and the hazard of erosion is moderate. Controlling erosion is the main concern of management.

Most areas are used for corn, oats, soybeans, and alfalfa. This soil is well suited to all crops grown in the county. Capability unit IIe–3, pasture group F, windbreak group 3.

Wc—Wentworth-Worthing silty clay loams. This complex is about 40 percent Wentworth soil, 30 percent Worthing soil, and 30 percent other soils. The areas consist of slight rises interrupted by many small circular depressions. Slopes are 0 to 3 percent. The Wentworth soil is on rises, and the Worthing soil is in depressions.

Included with these soils in mapping are small areas of Chancellor, Egan, and Wakonda soils. Egan soils are the most extensive and are on rises with the Wentworth soil. Chancellor soils are in narrow swales. Wakonda soils are on the rims of depressions or on the edges of some swales.

Runoff is slow, and water ponds on the Worthing soil. Spring planting commonly is delayed on the Worthing soil because it is poorly drained. The Wentworth soil has few or no limitations for crops. Overcoming wetness and maintaining tilth on the Worthing soil are the main concerns of management.

Most areas are used for crops. If the Worthing soil is adequately drained, this complex is suited to all crops grown in the county. In wet years, however, it is better suited to late-planted crops. Undrained areas of the Worthing soil are best suited to pasture or hay, but annual crops can be grown in dry years. Wentworth soil in capability unit I–2, pasture group F, windbreak group 3; Worthing soil in capability unit IIIw–1 drained and Vw–2 undrained, pasture group A drained and B undrained, windbreak group 10.

Whitewood Series

The Whitewood series consists of deep, somewhat poorly drained, nearly level, silty soils on bottom lands. These soils formed in alluvium. The native vegetation consisted mainly of tall grasses and a few deciduous trees along stream channels.

In a representative profile the surface layer is dark gray silty clay loam about 14 inches thick. The subsoil is silty clay loam about 28 inches thick. It is dark grayish brown in the upper part, gray in the middle, and grayish brown in the lower part. The underlying material is calcareous, light brownish gray silty clay loam.

Whitewood soils have high fertility and high organic-matter content. Permeability is moderately slow, and the available water capacity is high. These soils have a seasonal water table at a depth of 1 to 5 feet, and they are occasionally flooded.

Most areas are used for crops. A few areas are used for pasture.

Representative profile of Whitewood silty clay loam, in pasture, 123 feet north and 1,000 feet west of the southeast corner of sec. 14, T. 92 N., R. 50 W.

A1—0 to 5 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; few fine distinct strong brown (7.5YR 5/6) mottles, moist; weak fine granular structure; hard, friable, slightly sticky; neutral; clear smooth boundary.

A12—5 to 14 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; few fine distinct yellowish brown (10YR 5/6) mottles, moist; weak medium subangular blocky structure parting to weak fine granular; slightly hard, friable, slightly sticky; neutral; clear wavy boundary.

B21—14 to 25 inches; dark grayish brown (10YR 4/2) silty clay loam, very dark brown (10YR 2/2) moist; common fine distinct yellowish brown (10YR 5/6) mottles, moist, and few fine distinct dark reddish brown (5YR 2/2) mottles, moist; weak medium prismatic structure parting to moderate medium and fine subangular blocky; hard, friable, slightly sticky and slightly plastic; few fine dark concretions of iron and manganese oxides; few fine segregations of gypsum; neutral; gradual wavy boundary.

B22—25 to 30 inches; gray (10YR 5/1) silty clay loam, very dark gray (10YR 3/1) moist; common fine distinct yellowish brown (10YR 5/6) mottles, moist, and few fine faint gray mottles, moist; weak medium prismatic structure parting to weak medium and fine subangular blocky; hard, friable, slightly sticky and slightly plastic; few fine dark concretions of iron and manganese oxides; common fine segregations of gypsum; neutral; gradual wavy boundary.

B3g—30 to 42 inches; grayish brown (2.5Y 5/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; common fine distinct yellowish brown (10YR 5/6) mottles, moist, and few fine faint gray mottles, moist; weak coarse subangular blocky structure parting to weak medium and fine subangular blocky; hard, friable, slightly sticky and slightly plastic; common fine dark concretions of iron and manganese oxides; common fine segregations of gypsum; neutral; clear wavy boundary.

Cgca—42 to 60 inches; light brownish gray (2.5Y 6/2) silty clay loam, dark grayish brown (2.5Y 4/2) moist; many fine distinct yellowish brown (10YR 5/6), very dark brown

(10YR 2/2), and light gray (5Y 6/1) mottles, moist, and many fine faint dark gray mottles, moist; massive; hard, friable, slightly sticky and slightly plastic; common fine concretions of lime; strong effervescence; mildly alkaline.

Depth to lime ranges from 40 to 52 inches. The A horizon is dark or very dark gray silty clay loam or silt loam 14 to 20 inches thick. The B2 horizon ranges from dark gray to grayish brown in a hue of 10YR, 2.5Y, or 5Y. It is 14 to 20 inches thick. The B3g horizon is 4 to 12 inches thick. In places the C horizon below a depth of 40 inches is calcareous clay loam glacial till.

Whitewood soils are near Alcester, Egan, and Wentworth soils and are similar to Calco, Kennebec, and Lamo soils. Whitewood soils are more poorly drained than Alcester, Egan, Kennebec, and Wentworth soils. They are less calcareous than Calco and Lamo soils.

Wh—Whitewood silty clay loam. This is a nearly level soil on bottom lands along streams and drainageways. Slopes are 0 to 2 percent. The areas are long and narrow and range from 10 to 60 acres in size. In places recent overwash of grayish brown silt loam is on the surface.

Included with this soil in mapping are small areas of Chancellor, Kennebec, and Lamo soils. Chancellor soils are on the upper ends of drainageways. Kennebec soils are on the edges of valleys, generally on a slightly higher level. Lamo soils are in some low areas.

Runoff is slow. Wetness that results from flooding and from the high water table commonly delays planting in spring. This soil loses its tilth if farmed when wet. Overcoming wetness and maintaining tilth are the main concerns of management.

If adequately drained, this soil is well suited to all crops grown in the county. In wet years it is better suited to corn, soybeans, and sorghum than to early-sown crops. In undrained areas it is best suited to pasture and hay. Narrow areas that are dissected by meandering stream channels remain in native vegetation and are used for pasture. Capability unit IIw-2 drained and IVw-2 undrained, pasture group A drained and B undrained, windbreak group 2.

Worthing Series

The Worthing series consists of deep, poorly drained, silty soils that have a clayey subsoil. These soils are in depressions on uplands. They formed in alluvium washed from adjacent soils. The native vegetation consisted mainly of tall grasses, rushes, and sedges.

In a representative profile the surface layer is dark gray silty clay loam about 19 inches thick. The subsoil is silty clay about 26 inches thick. It is dark gray in the upper part and gray in the lower part. The underlying material is light olive gray and olive yellow silty clay loam.

Worthing soils have high fertility and high organic-matter content. Permeability is slow, and the available water capacity is high. These soils have a seasonal water table at a depth of 1 to 5 feet.

Most areas are adequately drained and are used for crops. A few areas are undrained and are used for pasture or hay.

Representative profile of Worthing silty clay loam, in cultivation, 1,300 feet west and 380 feet south of the northeast corner of sec. 21, T. 92 N., R. 50 W.

Ap—0 to 8 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak fine granular structure; hard, friable, slightly sticky and slightly plastic; slightly acid; abrupt smooth boundary.

A12—8 to 12 inches; dark gray (10YR 4/1) silty clay loam, black (10YR 2/1) moist; weak medium subangular blocky structure parting to weak fine granular; hard, friable, slightly sticky and slightly plastic; slightly acid; clear wavy boundary.

A13—12 to 19 inches; dark gray (10YR 4/1) silty clay loam, very dark gray (10YR 3/1) moist; few medium faint dark gray mottles, moist, and few fine distinct strong brown (7.5YR 5/6) mottles, moist; weak coarse and medium subangular blocky structure parting to weak fine subangular blocky; hard, friable, slightly sticky and slightly plastic; common fine pores; few visible sand grains and silt coatings on faces of peds; slightly acid; clear wavy boundary.

B21—19 to 28 inches; dark gray (5Y 4/1) silty clay, black (5Y 2/1) moist; few fine distinct strong brown (7.5YR 5/6) mottles, moist; weak coarse and medium prismatic structure parting to moderate medium and fine blocky; very hard, very firm, sticky and plastic; shiny faces on peds; neutral; gradual wavy boundary.

B22tg—28 to 36 inches; dark gray (5Y 4/1) silty clay, very dark gray (5Y 3/1) moist; few fine distinct strong brown (7.5YR 5/6) mottles, moist, and few medium faint dark olive gray mottles, moist; weak coarse and medium prismatic structure parting to moderate medium and fine blocky; very hard, very firm, sticky and plastic; shiny faces on peds; few fine dark concretions of iron and manganese oxides; neutral; gradual wavy boundary.

B23tg—36 to 45 inches; gray (5Y 5/1) silty clay, dark gray (5Y 4/1) moist; common fine distinct strong brown (7.5YR 5/6) and light olive brown (2.5Y 5/4) mottles, moist, and many medium and coarse faint olive gray mottles, moist; weak coarse prismatic structure parting to moderate medium blocky; very hard, very firm, sticky and plastic; shiny faces on peds; few fine dark concretions of iron and manganese oxides; neutral; gradual wavy boundary.

Cg—45 to 60 inches; light olive gray (5Y 6/2) and olive yellow (2.5Y 6/6) silty clay loam, olive gray (5Y 5/2) and light olive brown (2.5Y 5/6) moist; many fine distinct dark reddish brown (5YR 2/2) mottles, moist, and common fine faint gray mottles, moist; massive; very hard, firm, slightly sticky and slightly plastic; few medium segregations of lime; mildly alkaline.

Depth to free carbonates ranges from 40 to 60 inches or more. The A horizon is dark gray or very dark gray silty clay loam or heavy silt loam 12 to 20 inches thick. The B2t horizon ranges from very dark gray to gray in a hue of 10YR, 2.5Y, or 5Y. Some pedons have a B3 horizon. The C horizon is silty clay, silty clay loam, or clay loam.

Worthing soils are mapped with Chancellor and Wakonda soils and are near Wentworth soils. They are more poorly drained than all of these soils.

Wo—Worthing silty clay loam. This is a level soil in closed depressions. The areas are circular to oblong and commonly range from 3 to 10 acres in size, but some are as large as 30 acres. Slopes are 0 to 1 percent. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas of Wakonda soils on the rims of depressions.

Water ponds on this soil and remains on the surface until it evaporates. This soil compacts and loses its tilth if farmed when wet. Overcoming wetness and maintaining tilth are the main concerns of management.

If adequately drained, this soil is suited to crops. It is better suited to late-planted crops such as corn and soybeans than to early-sown crops. In undrained areas this soil is best suited to pasture, hay, or wildlife habitat. Capability unit IIIw-1 drained and Vw-2 undrained, pasture group A drained and B undrained, windbreak group 10.

Ws—Worthing-Chancellor silty clay loams. This complex is about 55 percent Worthing soil, 30 percent Chancellor soil, and 15 percent other soils. The areas are irregularly shaped and consist of 2 or more circular to oblong depressions joined by long, narrow swales. The Worthing soil is in depressions, and the Chancellor soil is in swales. Slopes are 0 to 2 percent. This Chancellor soil has the profile described as representative of the Chancellor series.

Included with these soils in mapping are small areas of Wakonda soils in narrow bands around depressions or on the edges of swales.

Runoff is slow on the Chancellor soil, and water ponds on the Worthing soil. Wetness that results from ponded water and from the seasonal water table commonly delays planting in spring. These soils compact and lose their tilth if farmed when wet. Overcoming wetness and maintaining tilth are the main concerns of management.

If the Worthing soil is adequately drained, this complex is suited to all crops grown in the county. It generally is better suited to late-planted crops than to spring-sown crops. In some undrained areas the Worthing soil is better suited to pasture or hay. Worthing soil in capability unit IIIw-1 drained and Vw-2 undrained, pasture group A drained and B undrained, windbreak group 10; Chancellor soil in capability unit IIw-1, pasture group A, windbreak group 2.

Use and Management of the Soils

This section discusses the use and management of the soils for crops and pasture, for trees and shrubs in windbreaks, for wildlife habitat, and for engineering purposes. Predicted average yields also are given for the principal crops under two levels of management.

Management of Cropland [2]

Cropland makes up about 82 percent of the total land area of Union County. Crops grow in all parts of the county, but the Sarpy-Grable-Haynie and Calco-Kennebec soil associations have a lower percentage of cropland than other major soil areas. The main crops are corn, oats, soybeans, and alfalfa.

The successful, long-term cultivation of any soil depends on managing that soil according to its capabilities and limitations. Management objectives in Union County are conserving moisture, controlling erosion and soil blowing, and maintaining fertility, content of organic matter, and tilth. Reduction of salinity and the use of drainage measures that reduce excessive wetness also are necessary on some soils.

A sound conservation cropping system tailored to the properties of each soil or group of soils is basic to meeting management objectives. Some soils can be used for a single crop for many years without damage to the physical condition of the soil. Other soils deteriorate rapidly when used continuously for one crop, especially if the crop is one that produces little residue. A cropping system based on soil properties helps to maintain tilth; reduce insect, disease, and weed infestations; and control erosion and soil blowing. In most cases, such a cropping system also helps to conserve moisture and maintain fertility and content of organic matter.

Conserving moisture generally means evenly distributing snow cover, reducing evaporation, limiting surface runoff, and controlling weeds. Among the measures that help to conserve moisture are minimum tillage, use of crop residue, contour farming, contour stripcropping, terracing (fig. 13), and timely tillage. These practices also help to control water erosion and soil blowing. Where needed, grassed waterways and diversions also help to control erosion. Usually a combination of practices is more effective than just one or two.

Among the practices that help to maintain tilth are minimum tillage, use of crop residue, timely tillage, use of green-manure crops, and grasses and legumes in the cropping system. These measures and the use of animal manure and chemical fertilizers help to maintain fertility and organic-matter content.

Some soils are more susceptible to soil blowing than others. On such soils, in addition to the practices named above, the use of cover crops and close-sown crops, wind stripcropping, field windbreaks, and spring plowing in place of fall plowing help to control soil blowing. Emergency tillage helps to control soil blowing until more permanent measures can be applied.

Some soils on bottom lands and in low areas in the uplands are too wet to be farmed early, but this wetness can be reduced by installing drainage structures and controlling the runoff from adjacent sloping soils. Selection of crops is also important. The natural drainage of the soil and the feasibility of installing artificial drainage must be determined onsite.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are so used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to horticultural or other specialty crops that require special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for forest trees, or for engineering.

In the capability system, the kinds of soils are grouped at three levels: the capability class, the subclass, and the unit. These are described in the following paragraphs.

CAPABILITY CLASSES, the broadest group, are designated by Roman numerals I to VIII. The numbers indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VI soils have severe limitations that make them generally unsuitable for cultivation and limit their

[2] By PAUL M. BODEN, conservation agronomist, Soil Conservation Service.

Figure 13.—**Terracing on Crofton-Nora silt loams, 6 to 12 percent slopes, eroded.**

use largely to pasture or range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuitable for cultivation and restrict their use largely to pasture or range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, water supply, or esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class. They are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral; for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

Class I contains no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, although they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management (*6*). Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol; for example, IIe-1 or IIIs-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraphs; and the Arabic numeral specifically identifies the capability unit within each subclass.

On the following pages the capability units in Union County are described, and suggestions for their use and management are given. The capability units within a capability subclass are not numbered consecutively because not all of the units in the statewide system are used in this county. To find the capability classification of a given soil in this county, refer to the "Guide to Mapping Units" at the back of this survey.

CAPABILITY UNIT I-1

This unit consists of deep, well drained and moderately well drained, nearly level soils on botton lands. These soils have a surface layer of loam, silt loam, or silty clay loam.

Most have similar textures in the underlying layers, but one soil is silty clay at a depth of about 24 inches.

These soils are easy to work and have medium to high fertility. The available water capacity is high in most soils. Some have a seasonal high water table and some are subject to flooding, but in most years the additional moisture is beneficial and wetness is not a problem. Runoff is slow. There is no hazard of erosion and soil blowing, or the hazard is only slight. These soils can be farmed intensively without damage. Maintaining fertility is the main concern of management.

These soils are used mostly for corn, soybeans, oats, and alfalfa. They also are well suited to tame and native grasses. Most of the soils are well suited to irrigation.

Managing crop residue, using grasses and legumes in the cropping system, and applying fertilizer help to maintain fertility. Plowing in spring or leaving fields rough after fall plowing helps to control soil blowing.

CAPABILITY UNIT I-2

This unit consists of deep, well drained, nearly level soils on uplands. These soils have a surface layer and subsoil of silty clay loam.

These soils are easy to work and have high fertility. The available water capacity is high, and permeability is moderate. Runoff is slow, and the hazard of erosion is slight. These soils have only slight limitations for crops and can be farmed intensively.

These soils are used mainly for corn, soybeans, oats, and alfalfa. They also are well suited to tame grasses.

Managing crop residue, using grasses and legumes in the cropping system, and applying fertilizer help to maintain fertility and tilth.

CAPABILITY UNIT I-3

Graceville silty clay loam is the only soil in this unit. It is a moderately well drained, nearly level soil on stream terraces. It has a subsoil of silty clay loam and is underlain by gravelly sand at a depth of about 52 inches.

This soil has high fertility. The available water capacity is high, and permeability is moderate. Runoff is slow. Some areas receive runoff from adjacent soils, but the additional moisture generally is beneficial. This soil has few limitations for crops.

All areas are used for crops. Corn, soybeans, and alfalfa are the main crops. This soil also is well suited to small grain and tame grasses.

Managing crop residue, using grasses and legumes in the cropping system, and applying fertilizer help to maintain fertility.

CAPABILITY UNIT IIe-1

Alcester silt loam, 2 to 6 percent slopes, is the only soil in this unit. It is a moderately well drained, gently sloping soil on foot slopes and along drainageways. It has a subsoil of silt loam.

This soil is easy to work and has high fertility. The available water capacity is high, and permeability is moderate. Runoff is medium. Most areas receive beneficial moisture as runoff from adjacent sloping soils. Gullies form easily in the drainageways, however, and controlling erosion is the main concern of management.

Most areas are used for corn, soybeans, small grain, and alfalfa. This soil is also well suited to sorghum and tame grasses.

Proper management of crop residue and contour farming help to control erosion. Grassed waterways help to prevent gullying.

CAPABILITY UNIT IIe-3

This unit consists of deep, well drained, gently sloping soils on uplands. The surface layer is silty clay loam, and the subsoil is silty clay loam or silt loam.

These soils are easy to work and have medium or high fertility. The available water capacity is high. All of these soils have moderate permeability in the subsoil, but in places permeability is moderately slow in the underlying material. Runoff is medium, and the hazard of erosion is moderate. Controlling erosion is the main concern of management. Conserving moisture, controlling soil blowing, and maintaining fertility are also concerns.

Most areas are cultivated and are used for corn, soybeans, small grains, and alfalfa. These soils also are suited to tame and native grass pasture.

Contour farming and terracing help to control erosion and conserve moisture. If slopes are too irregular for these mechanical practices, erosion and soil blowing can be controlled by properly managing crop residue and using more close-sown crops.

CAPABILITY UNIT IIe-4

The Wakonda part of the Wakonda-Worthing-Chancellor complex is the only soil in this unit. It is a deep, moderately well drained, nearly level soil on uplands. It is silt loam throughout and has a high content of lime.

This soil has medium fertility. The available water capacity is high, and permeability is moderate. Runoff is slow. The high content of lime causes this soil to blow easily and also affects crop growth. In some years wetness from a seasonal high water table delays planting and tillage. Controlling soil blowing and improving fertility are the main concerns of management but improving drainage and maintaining tilth are also concerns.

Most areas are cultivated and are used for corn, soybeans, small grain, sorghum, and alfalfa. This soil also is suited to tame and native grass pasture.

Proper management of crop residue, wind stripcropping, and leaving the surface rough after fall plowing help to control soil blowing. Applying animal manure and fertilizer helps to maintain fertility and tilth. If outlets are available, the water table can be lowered by underground drains.

CAPABILITY UNIT IIw-1

This unit consists of deep, somewhat poorly drained and poorly drained, level and nearly level soils. These soils are mostly on bottom lands, but some are in swales and depressions on uplands. The surface layer commonly is silty clay loam, and all of these soils have a layer of silty clay in the subsoil or underlying material.

These soils have medium or high fertility. Permeability is moderately slow to very slow in some parts of the profile. The available water capacity is moderate or high in most soils but is low or moderate in some. Wetness that results from a seasonal high water table or from flooding commonly delays planting and tillage, but in most years drainage is adequate for intensive cropping. These soils compact and lose their tilth if farmed when wet. Overcoming wetness, improving water intake rate, and maintaining tilth are the main concerns of management. Controlling soil blowing is a concern in some areas.

Most areas are used for corn, soybeans, small grain, and alfalfa. In wet years these soils are better suited to late-planted crops than to small grain. They also are suited to tame and native grass pasture.

Surface or underground drains help to control wetness. Managing crop residue, minimum tillage, and timely tillage help to maintain tilth, improve water intake rate, and control soil blowing. Fall plowing generally is more satisfactory than spring plowing.

CAPABILITY UNIT IIw-2

Whitewood silty clay loam is the only soil in this unit. It is a somewhat poorly drained, nearly level, silty soil on narrow bottom lands. It has a surface layer and subsoil of silty clay loam.

This soil has high fertility. The available water capacity is high, and permeability is moderately slow. Runoff is slow. Wetness that results from flooding and from a seasonal high water table commonly delays planting and tillage, but if these soils are properly drained, they can be used for crops in most years. Controlling wetness, maintaining tilth, and improving water intake rate are the main concerns of management.

In drained areas, this soil is suited to corn, soybeans, small grain, sorghum, alfalfa, and tame grasses. It is better suited to late-planted crops such as corn, soybeans and sorghum than to early-sown crops.

If outlets are available, the water table can be lowered by underground drains. Constructing dikes, floodwater diversions, or floodways to remove excess water help to reduce damage from flooding. Proper management of crop residue, minimum tillage, and timely tillage help to maintain tilth.

CAPABILITY UNIT IIw-3

This unit consists of deep, moderately well drained to poorly drained, level soils on bottom lands. The surface layer and the upper part of the underlying material are silty clay loam or silty clay. At a moderate depth the underlying material ranges from silty clay loam to fine sand.

These soils have medium to high fertility. The available water capacity is moderate or high in most areas but low in the soil that has sandy underlying material. Permeability is moderate to slow in the upper part of these soils but moderate to rapid in the underlying layers. Wetness that results from flooding and from a seasonal high water table commonly delays planting and tillage, but drainage is adequate for intensive cropping in most years. These soils compact and lose their tilth if farmed when wet. Controlling wetness, improving water intake rate, and maintaining tilth and fertility are the main concerns of management.

Most areas are used for corn, soybeans, small grain, and alfalfa. These soils are better suited to late-planted crops such as corn, soybeans, and sorghum than to early-sown crops. They are suited to tame and native grass pasture.

If outlets are available, the water table can be lowered by underground drains. Constructing dikes, floodwater diversions, or floodways to remove excess water helps reduce damage from flooding. Proper management of crop residue and minimum tillage helps maintain tilth and improve water intake rate. Applying fertilizer helps to maintain fertility.

CAPABILITY UNIT IIs-3

This unit consists of well drained and somewhat excessively drained, nearly level soils that are moderately deep over gravelly sand, gravelly loamy sand, or fine sand. These soils are on terraces and bottom lands. They have a surface layer of loam, silt loam, and silty clay loam.

These soils are easy to work and have medium fertility. Because the available water capacity is moderate or low, the soils are somewhat droughty. Permeability is moderate in the upper layers but rapid in the underlying gravelly material. Runoff is slow. Conserving moisture is the main concern of management. Controlling soil blowing and maintaining fertility are also concerns.

Most areas are cultivated and are used for corn, oats, soybeans, and alfalfa. Some areas are irrigated. Soils in nonirrigated areas are better suited to early-maturing crops, such as small grain and tame grasses, than to late-maturing crops, such as corn and soybeans. The soils also are suited to tame and native grass pasture.

Proper management of crop residue and wind stripcropping help to conserve moisture and control soil blowing. Leaving the surface rough after fall plowing helps to catch moisture and control soil blowing. Applying fertilizer helps to maintain fertility.

CAPABILITY UNIT IIIe-2

This unit consists of deep, well drained, sloping soils on uplands. These soils have a surface layer of silty clay loam and a subsoil of silty clay loam or silt loam.

These soils are easy to work and have high or medium fertility. The available water capacity is high. Permeability is mostly moderate, but one soil in this unit has moderately slow permeability in the underlying material. Runoff is medium, and the hazard of erosion is severe—especially if row crops are grown. Controlling erosion is the main concern of management. Maintaining fertility and tilth and conserving moisture are also concerns.

Most areas are used for corn, oats, soybeans, and alfalfa. Some areas are in tame grass and are used for pasture and hay.

Proper management of crop residue, terracing, and grassed waterways help to control erosion and conserve moisture. If slopes are too irregular for mechanical controls, using fewer row crops and more small grain, tame grasses, and legumes in the cropping system helps to control erosion and conserve moisture. Applying fertilizer helps to maintain fertility.

CAPABILITY UNIT IIIe-6

This unit consists of deep, well drained, gently sloping and gently undulating soils on uplands. The surface layer is silt loam or clay loam. These soils are calcareous at a depth of 8 inches.

These soils are easy to work but have low or medium fertility. The available water capacity is high. Permeability is mostly moderate in the subsoil or underlying material, but one soil in this unit has moderately slow permeability in the underlying material. Runoff is medium. Controlling erosion and soil blowing and improving fertility are the main concerns of management. Conserving moisture is also a concern.

Most areas are cultivated and are used for corn, soybeans, oats, and alfalfa. These soils are suited to crops and also to tame and native grass pasture.

Contour farming, terracing, and grassed waterways help to control erosion and conserve moisture. If slopes are too irregular for mechanical controls, using more small grain, tame grasses, and legumes in the cropping system helps to control erosion and conserve moisture. Proper management

of crop residue, minimum tillage, and plowing in spring rather than in fall also help to control erosion and soil blowing. Applying animal manure and chemical fertilizer helps to improve fertility.

CAPABILITY UNIT IIIw-1

This unit consists of deep, poorly drained, level soils in depressions on uplands. The surface layer is silty clay loam, and the subsoil is silty clay.

These soils have high fertility and high available water capacity. Water ponds on these soils, and they commonly remain wet during spring. However, drainage either has been provided or is feasible, and crops can be grown in most years. These soils compact and lose their tilth if farmed when wet. Maintaining adequate drainage and good tilth is the main concern of management.

If adequately drained, these soils are suited to corn, soybeans, and small grain. The survival of alfalfa depends on the degree of wetness in the soil. Red clover, alsike clover, and Ladino clover can be planted instead of alfalfa. During wet years, these soils are better suited to late-planted crops than to small grain, but the maturing of crops before a killing frost is critical. Maintaining or installing surface or subsurface drains helps to reduce wetness. Proper management of crop residue and timely tillage help to maintain tilth.

CAPABILITY UNIT IIIw-2

This unit consists of deep, poorly drained, level soils on bottom lands. These soils are silty clay throughout.

These soils have medium or high fertility but are difficult to work. They compact and lose their tilth if farmed when wet. Permeability is slow or very slow, and the available water capacity is low or moderate. Runoff is slow. These soils have a high water table and in places are subject to flooding, but drainage is provided or is feasible. The soils dry slowly, and wetness commonly delays planting and tillage. Overcoming wetness and maintaining tilth are the main concerns of management. Maintaining fertility and improving water intake rate are also concerns.

If adequately drained and protected from flooding, these soils are suited to corn, soybeans, sorghum, small grain, and alfalfa. The survival of alfalfa depends on the degree of wetness in the soil. In years that have a wet spring these soils are better suited to early-maturing varieties of corn, soybeans, and sorghum than to spring-sown small grain.

Dikes or floodwater diversions help to reduce damage from flooding. Maintaining or constructing deep, open drains helps to remove excess water and regulate the depth of the water table. Properly managing crop residue, timely tillage, and grasses and legumes in the cropping system help to improve water intake rate and maintain fertility and tilth. Applying fertilizer helps to maintain fertility.

CAPABILITY UNIT IIIw-3

Salmo silty clay loam, somewhat poorly drained, is the only soil in this unit. It is a calcareous soil on bottom lands and has a high content of salts. The underlying material is silt loam and silty clay loam.

This soil has medium fertility. The available water capacity is high, and permeability is moderately slow. Runoff is slow. Wetness that results from flooding and from the high water table delays planting and tillage in some years. Overcoming wetness and controlling salinity are the main concerns of management. Maintaining tilth and fertility are also concerns.

Most areas are used for crops. These soils are better suited to corn, soybeans, and sorghum than to spring-sown small grain because they are wet in spring. This soil also is suited to tame and native grass pasture.

Maintaining existing drainage systems or constructing open and underground drains helps to remove excess water and lower the water table. It also helps leach salts from the upper part of the soil. Dikes or floodwater diversions help to reduce damage from flooding. Proper management of crop residue, timely tillage, and the use of grasses and legumes in the cropping system help to maintain tilth and fertility. Applying animal manure and fertilizer helps to maintain fertility.

CAPABILITY UNIT IIIs-2

Only Enet and Dempster soils, 2 to 6 percent slopes, is in this unit. These are well drained soils that are underlain by gravelly sand and gravelly loamy sand at a moderate depth. The surface layer is loam and silty clay loam. The subsoil is silty clay loam and silt loam or loam and sandy loam.

These soils are easy to work and have medium fertility. Because the available water capacity is low or moderate, the soils are somewhat droughty. Permeability is moderate in the subsoil and rapid in the gravelly underlying material. Runoff is medium, and the hazards of erosion and soil blowing are moderate. Conserving moisture and controlling erosion and soil blowing are the main concerns of management. Maintaining fertility is also a concern.

These soils are used for corn, small grain, soybeans, and alfalfa. A few areas are irrigated. In nonirrigated areas these soils are better suited to small grain and tame grasses than to corn and soybeans. They are also suited to tame and native grass pasture.

Proper management of crop residue and contour farming help to conserve moisture and control erosion. If slopes are too irregular for contour farming, row crops should be omitted from the cropping system to conserve moisture and control erosion. Leaving the fields rough after fall plowing helps to control soil blowing and also helps to conserve moisture by catching snow. Applying fertilizer helps to maintain fertility.

CAPABILITY UNIT IIIs-4

Storla loam is the only soil in this unit. It is a somewhat poorly drained, nearly level soil on bottom lands. It is underlain by gravelly sand and has a high content of lime.

This soil has medium fertility. Crop growth is affected by the high content of lime in the layers below the surface. Wetness caused by a seasonal high water table delays planting in some years, but the soil is droughty late in summer because of the underlying gravelly sand. Permeability is moderate in the upper part of the soil but rapid in the underlying gravelly sand. Runoff is slow. Conserving moisture and improving fertility are the main concerns of management. Controlling soil blowing and maintaining tilth are also concerns. Improved drainage is needed in some areas.

Most areas are used for corn, soybeans, oats, and alfalfa. In dry years this soil is better suited to spring-sown small grain and tame grasses than to row crops. Proper management of crop residue, timely tillage, and grasses and legumes in the cropping system help to conserve moisture and maintain tilth and fertility. Applying animal manure and fertilizer helps to improve fertility.

CAPABILITY UNIT IVe-2

This unit consists of deep, well drained, sloping to strongly sloping soils on uplands. These soils are silt loam or clay loam throughout, and most are calcareous at a depth of 8 inches or less. Some of the soils are moderately eroded to severely eroded.

These soils are easy to work but have low or medium fertility. The hazards of erosion and soil blowing are severe. The available water capacity is high, and permeability is moderate to moderately slow. Runoff is medium. Controlling erosion and soil blowing and improving fertility are the main concerns of management. Improving the organic-matter content and conserving moisture in the soil are also concerns.

Most areas are used for corn, oats, alfalfa, and tame grasses. These soils are better suited to close-sown crops than to row crops because of the severe erosion hazard. They are also suited to tame and native grass pasture.

Proper management of crop residue, minimum tillage, contour farming (fig. 14), terracing, and grassed waterways help to control erosion and conserve moisture. Including grasses and legumes in the cropping system, using green-manure crops, and applying fertilizer help to improve fertility and organic-matter content.

Some areas remain in native grasses and are used for pasture. Important grasses include big bluestem, little bluestem, western wheatgrass, green needlegrass, needleandthread, and sideoats grama. If these pastures are in excellent condition, the annual air-dry yield per acre ranges from about 2,300 pounds in a dry year to about 4,300 in a year of favorable moisture.

CAPABILITY UNIT IVe-3

Thurman fine sandy loam, 3 to 9 percent slopes, is the only soil in this unit. It is a deep, somewhat excessively drained, gently undulating to undulating soil on uplands and terrace fronts. The surface layer is fine sandy loam, and the underlying material is mainly loamy fine sand.

This soil takes in water readily, but the available water capacity is low or moderate and the soil is somewhat droughty. Fertility is medium, and organic-matter content is moderately low. Permeability is rapid. Runoff is slow, but cultivated areas are subject to soil blowing and erosion. Controlling soil blowing and conserving moisture are the main concerns of management. Maintaining fertility and organic-matter content is also a concern.

Most areas are used for crops. This soil is better suited to crops that provide a cover throughout the year than to row crops because of the hazard of soil blowing. This soil also is suited to pasture and hay.

Properly managing crop residue, minimum tillage, close-

Figure 14.—**Contour stripcropping in an area of Crofton-Nora silt loams, 6 to 12 percent slopes, eroded.**

sown crops in the cropping system, and field windbreaks help to control soil blowing and erosion and to conserve moisture. Plowing in spring rather than in fall helps to reduce the risk of soil blowing. Including grasses and legumes in the cropping system, using green-manure crops, and applying animal manure help to maintain fertility and organic-matter content.

CAPABILITY UNIT IVw-2

This unit consists of deep, somewhat poorly drained and poorly drained, level and nearly level soils on bottom lands. These soils are not drained, or drainage is not feasible. These soils have a surface layer of silty clay loam or silty clay. The underlying layers of some soils have these same textures, but some have coarser textures.

These soils have medium or high fertility but are difficult to work. Runoff is slow, and the soils are wet for extended periods because of flooding and the seasonal high water table. Wetness delays planting and tillage and retards crop growth. These soils compact and lose their tilth if farmed when wet. One soil has a high content of salts. Reducing wetness and maintaining tilth are the main concerns of management.

Many areas are used for crops. The soils generally are too wet in spring for small grain. Alfalfa grows poorly in most areas because of wetness. Late-planted crops grow well in some years if early-maturing varieties are selected. Many areas are best suited to tame and native grass pasture or wildlife habitat.

Dikes or floodwater diversions help to reduce damage from flooding. Reducing runoff from adjacent up'ands helps to reduce wetness in some areas. Properly managing crop residue, timely tillage, and including clovers in the cropping system help to maintain tilth and fertility.

Some areas remain in native vegetation and are used for pasture or hay. Important grasses are big bluestem, prairie cordgrass, switchgrass, western wheatgrass, and sedges. If these pastures are in excellent condition, the annual air-dry yield per acre is about 5,000 pounds.

CAPABILITY UNIT IVs-1

This unit consists of deep, excessively drained, level and nearly level soils on bottom lands. The surface layer ranges from fine sand to silty clay. The underlying material is stratified loamy fine sand and fine sand.

These soils have low fertility and low organic-matter content. They are subject to soil blowing. The available water capacity is low, and the soils are droughty. Permeability is rapid. Runoff is slow, and most areas are subject to flooding. Areas that have a surface layer of silty clay lose their tilth if farmed when wet. Controlling soil blowing, conserving moisture, and improving soil fertility and organic-matter content are concerns of management. Maintaining tilth is a concern in places.

Many areas are used for crops. Unless irrigated, these soils are best suited to small grain and tame grasses. They can be irrigated, but the water intake rate is rapid and fertility is low.

Properly managing crop residue, minimum tillage, field windbreaks, and a cover of close-sown crops or stubble help to control soil blowing and conserve moisture. Using green-manure crops and applying animal manure and fertilizer help to improve fertility and organic-matter content.

Some areas remain in native grass and are used for pasture. Important grasses are big bluestem, indiangrass, little bluestem, prairie cordgrass, and switchgrass. If these pastures are in excellent condition, the annual air-dry yield per acre is about 3,500 pounds. The yield is higher in places that have a water table within a depth of 6 feet.

CAPABILITY UNIT Vw-2

This unit consists of deep, poorly drained, level and nearly level soils on bottom lands and in closed depressions. Most of the soils have a surface layer of silty clay or silty clay loam underlain by similar textures, but mixed alluvial soils that range from loamy sand to clay are in some areas.

These soils are subject to flooding and have a high water table during much of the growing season. These soils are too wet to cultivate, and drainage is not feasible in most areas.

Nearly all areas remain in native vegetation and are used for pasture or hay. Some areas are used for hay where the water table lowers enough to permit haying late in summer. Some areas are used for wildlife habitat.

The native vegetation was mainly prairie cordgrass, reed canarygrass, and slough sedge. Willows grew on some bottom land. If the native pastures are in excellent condition, the annual air-dry yield per acre is about 6,500 pounds.

CAPABILITY UNIT VIe-1

The Nora part of Nora-Crofton silt loams, 20 to 50 percent slopes, is the only soil in this unit. It is a deep, well drained, mostly moderately steep soil on uplands. It is silt loam throughout.

This soil has medium fertility and high available water capacity, but it is too steep and erodible to be cultivated. Permeability is moderate, and runoff is rapid. Controlling erosion is the main concern of management.

Nearly all areas remain in native vegetation and are used for pasture. Native trees and shrubs are in some areas. In a few places some native trees are used for timber products, but the trees are valued mainly for livestock protection, wildlife habitat, and recreation.

Proper grazing of native grasses helps to control erosion. Important grasses are big bluestem, green needlegrass, little bluestem, needleandthread, and western wheatgrass. If these pastures are in excellent condition, the annual air-dry yield per acre ranges from 2,450 pounds in a dry year to about 4,000 pounds in a year of favorable moisture.

CAPABILITY UNIT VIe-3

This unit consists of deep, well drained, strongly sloping to steep soils on uplands. These soils are silt loam or clay loam throughout and are calcareous at a depth of 8 inches or less. Some areas are moderately to severely eroded.

These soils have low to medium fertility and high available water capacity, but they are too steep and erodible to cultivate. Permeability is moderate to moderately slow. Runoff is medium to rapid. Controlling erosion is the main concern of management. Conserving moisture is also a concern.

These soils are best suited to pasture and hay. Some areas are used for crops or were formerly cultivated and have been seeded to tame grass. Erosion in cultivated areas can best be controlled by establishing a grass cover. Proper grazing and contour furrows help to control erosion and conserve moisture in pasture.

Some areas remain in native grass and are used for pasture. Important grasses are big bluestem, green needlegrass, little bluestem, needleandthread, sideoats grama, and western wheatgrass. If these pastures are in excellent condition, the annual air-dry yield per acre ranges from about 2,300 pounds in a dry year to 4,300 pounds in a year of favorable moisture.

CAPABILITY UNIT VIs-1

Sarpy loamy fine sand, 3 to 9 percent slopes, is the only soil in this unit. It is a deep, excessively drained, sandy soil on bottom lands. The underlying material is stratified loamy fine sand and fine sand.

This soil has low fertility and low organic-matter content. The hazard of soil blowing is very severe. The available water capacity is low, and the soil is droughty. Permeability is rapid. Runoff is slow. This soil is not suited to cultivated crops because of the soil blowing hazard and droughtiness.

Most areas remain in native pasture and are used for pasture. Some areas are wooded. Maintaining a good grass cover helps to control soil blowing and conserve moisture. Important grasses are big bluestem, little bluestem, needleandthread, prairie sandreed, sand bluestem, and switchgrass. If these pastures are in excellent condition, the annual air-dry yield per acre ranges from 1,800 pounds in a dry year to 3,500 pounds in a year of favorable moisture.

CAPABILITY UNIT VIIe-1

The Crofton part of Nora-Crofton silt loams, 20 to 50 percent slopes, is the only soil in this unit. It is deep, well drained, and moderately steep to very steep. It is calcareous silt loam to a depth of 60 inches or more.

This soil has high available water capacity, but it is too steep and erodible to cultivate. Permeability is moderate. Runoff is rapid. Controlling erosion is the main concern of management.

All areas remain in native vegetation and are used for pasture, wildlife habitat, and recreation. Some areas are wooded. Proper grazing helps to control erosion. Shaping and reseeding gullies and using structures to stabilize grade help to control gully erosion.

Important native grasses are big bluestem, little bluestem, needleandthread, and sideoats grama. If these pastures are in excellent condition, the annual air-dry yield per acre ranges from about 2,000 pounds in a dry year to about 4,000 pounds in a year of favorable moisture.

CAPABILITY UNIT VIIIw-1

This unit consists of areas of Fluvaquents, wet, that should not be grazed. These areas are in shallow basins and former stream channels on bottom lands. Water is at or near the surface during the growing season in most years.

These areas are too wet for crops or pasture and hay plants. They are best suited to wildlife habitat. The vegetation is mainly rushes, cattails, willows, and other aquatic plants. Wildlife habitat can be improved by constructing level ditches or shallow pits to provide open-water areas.

Use of the soils for tame pasture [3]

Most of Union County was once covered by grass. Small scattered areas are still in native grass, but tame grass pastures now provide most of the grazing for livestock. Tame pasture is a practical, economically feasible land use for most soils in the county (fig. 15).

The primary objectives of pasture management are maintaining vigorous stands of palatable, well adapted forage for livestock feed; improving the soil; and controlling erosion. Proper grazing, adequate fertilization, clipping, and weed control help to meet these objectives.

[3] By PAUL M. BODEN, conservation agronomist, Soil Conservation Service.

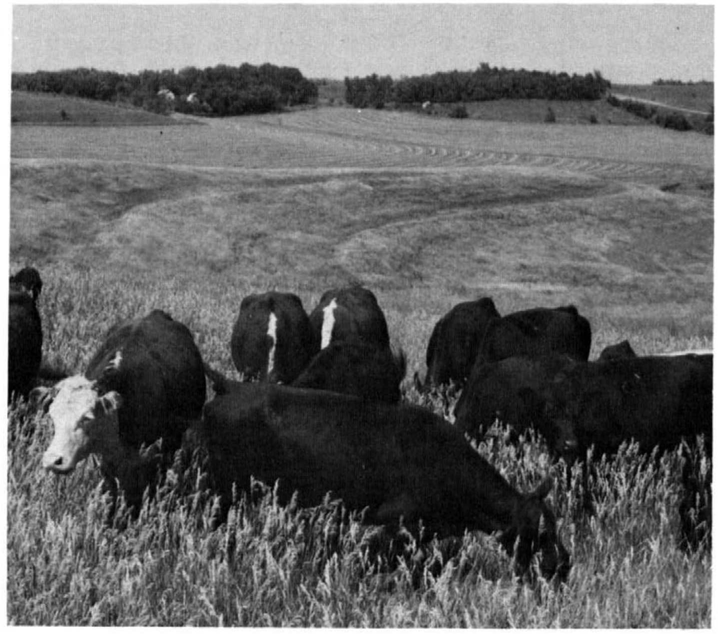

Figure 15.—**Tame grass pasture on Crofton silt loam, 12 to 17 percent slopes, eroded.**

Proper grazing includes delaying grazing until vegetation has a good start in spring, never grazing too closely, rotation grazing, grazing at the optimum time, and periodic resting. The addition of fertilizer as needed helps to maintain an adequate supply of plant nutrients. Clipping helps to distribute grazing and stimulate even regrowth. Where the stand is thin, control of weeds by mowing or spraying results in more available moisture and plant nutrients for desirable pasture plants.

Soils that are steep or very wet are not suited to tame pasture. They are suited to native pasture, which requires management that maintains the native vegetation.

The soils of Union County that are suitable for tame pasture are placed in eight pasture groups. The following paragraphs give descriptions of the pasture groups, and important soil characteristics, and suitable pasture plants for each group. The letters used to identify the pasture groups are not in consecutive order because not all of the groups in the statewide system are used in Union County. To find the pasture group of a given soil, refer to the "Guide to Mapping Units" at the back of this survey.

PASTURE GROUP A

This group consists of deep, somewhat poorly drained to very poorly drained soils on bottom lands and in depressions and low areas on uplands. These soils have a water table within the root zone. They also receive additional moisture from stream flooding or as runoff from adjacent soils. These soils are either artificially drained or the water table is at a shallow depth for such a short time that plant growth is not adversely affected.

These soils are suited to all adapted grasses and legumes, but only plants capable of using the extra moisture are recommended. Among such plants are alfalfa, big bluestem, creeping foxtail, indiangrass, intermediate wheatgrass, reed canarygrass, smooth bromegrass, and switchgrass.

PASTURE GROUP B

This group consists of deep, somewhat poorly drained and poorly drained, silty and clayey soils on bottom lands and in depressions on uplands. These soils have a water table within the root zone. They also receive additional moisture from stream flooding or as runoff from adjacent soils. These soils are not artificially drained, and in many areas improving drainage is not feasible.

The excess moisture in these soils limits the choice of pasture and hay plants to water-tolerant species. Among such plants are creeping foxtail, reed canarygrass, and western wheatgrass.

PASTURE GROUP D

This group consists of silty and loamy soils that are moderately deep over gravelly sand. These soils are on bottom lands and stream terraces. Most are well drained to somewhat excessively drained, but one has a seasonal high water table in spring and is somewhat poorly drained. All of these soils, however, are somewhat droughty late in summer.

The choice of plants and the production of forage plants are limited by the less than optimum available water capacity. The soils are suited to alfalfa, intermediate wheatgrass, and smooth bromegrass.

PASTURE GROUP F

This group consists of deep, well drained and moderately well drained, nearly level to steep, silty soils on bottom lands and uplands. These soils have medium or high fertility and high available water capacity. Permeability is moderate in the subsoil, but it is moderately slow in the underlying material of one soil.

These soils are suited to all adapted plants, except they are not suited to bunch grasses planted alone if slopes are more than 6 percent. Among the suitable grasses and legumes are alfalfa, big bluestem, green needlegrass, indiangrass, intermediate wheatgrass, smooth bromegrass, and switchgrass.

PASTURE GROUP G

This group consists of deep, well drained, gently sloping to steep, silty and loamy soils that are calcareous within 8 inches of the surface. These soils are on uplands. They have a high available water capacity but low or medium fertility. The erosion hazard is severe.

The choice of plants and the production of forage plants are limited by the high content of lime and the severe erosion hazard. Where slopes are more than 6 percent, the soils are not suited to bunch grasses planted alone. Among the suitable grasses and legumes are alfalfa, crested wheatgrass, intermediate wheatgrass, pubescent wheatgrass, and smooth bromegrass.

PASTURE GROUP H

This group consists of deep, excessively drained and somewhat excessively drained, level to undulating soils that have a sandy to clayey surface layer and have sandy underlying material at a shallow depth. These soils have low to medium fertility, low or moderate available water capacity, and rapid permeability. They are highly susceptible to soil blowing.

The choice of plants is limited by droughtiness and the severe soil blowing hazard. The soils of this group are suited to such grasses and legumes as alfalfa, big bluestem, indiangrass, intermediate wheatgrass, smooth bromegrass, and switchgrass.

PASTURE GROUP J

This group consists of deep, poorly drained and somewhat poorly drained, silty and clayey soils that have a high content of salts at or near the surface. These soils are on bottom lands. They have a high water table and are subject to flooding.

The choice of plants is severely limited by wetness and salinity. Among the suitable pasture plants are tall wheatgrass and western wheatgrass.

PASTURE GROUP K

This group consists of deep, moderately well drained, silty and loamy soils on bottom lands and terraces. These soils receive additional moisture from stream flooding or as runoff from adjacent soils. Some soils have a seasonal high water table for short periods during spring. Most soils have high fertility, high available water capacity, and moderate permeability.

These soils are suited to all adapted plants. Because of the favorable moisture, the production of forage plants is higher than on nearby, well drained soils. Among the suitable grasses and legumes are alfalfa, big bluestem, creeping foxtail, indiangrass, intermediate wheatgrass, reed canarygrass, smooth bromegrass, and switchgrass.

Predicted yields

Table 2 lists the predicted average yields per acre of corn, oats, soybeans, alfalfa, and pasture for each soil in the county suitable for crops or tame pasture. The predictions are for dryfarmed soils under two levels of management. Predicted yields of irrigated crops are not available. The irrigated acreage in the county is small and is mostly in corn. Yields can be increased on most soils in the county if enough water is applied and a high level of management is used.

Columns A of table 2 show yields that can be expected under an average level of management, the level most commonly practiced in this county. An average level of management includes some practices common to a high level, but differences exist in one or more of the requirements.

Columns B of table 2 show yields that can be expected under a high, or improved, level of management. This is the level of management practiced by those farmers who maintain soil productivity at high levels while using their land within its capability and protecting it from erosion. High level management of cropland and tame pasture includes the following:

1. Using a planned conservation cropping system.
2. Using commercial fertilizers in amounts indicated by soil tests for high production.
3. Using crop residues and green manure crops or animal manures to maintain or improve tilth and organic-matter content.
4. Using crop or grass varieties, seed quality, and plant populations recommended for a particular soil.
5. Limiting seedbed preparation to that necessary for crop or pasture production.
6. Providing surface or internal drainage for optimum

TABLE 2.—*Predicted average annual yields per acre of principal dryfarmed crops and tame pasture*

[Yields in columns A can be expected under prevailing management; yields in columns B can be expected under improved management. Only soils suitable for crops or tame pasture are listed. The absence of a yield figure indicates that the crop is not commonly grown on the soil or that the soil is not suited to the crop. Yields for soil complexes are weighted averages based on the proportionate extent and relative productivity of the soils in the complex]

Soil	Corn		Oats		Soybeans		Alfalfa		Pasture	
	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*AUM* [1]	*AUM*
Albaton silt loam, overwash	53	74	42	58	20	28	2.4	3.6	3.7	5.8
Albaton silty clay	50	70	38	54	18	26	2.1	3.4	3.4	5.5
Albaton silty clay, depressional									2.6	4.3
Alcester silt loam, 2 to 6 percent slopes	70	88	53	80	20	33	2.8	3.9	4.7	6.5
Benclare silty clay loam, somewhat poorly drained	61	80	54	76	20	29	2.7	3.5	4.5	5.8
Benclare soils, overwash	63	84	56	79	21	32	2.8	3.8	4.6	6.0
Blencoe silty clay	60	78	52	76	21	28	2.5	3.4	4.2	5.7
Blyburg silt loam	73	92	58	80	26	38	3.0	4.2	4.8	6.7
Calco silty clay loam, wet									3.8	5.3
Crofton silt loam, 12 to 17 percent slopes, eroded									2.7	4.0
Crofton silt loam, 17 to 30 percent slopes									2.3	3.5
Crofton-Nora silt loams, 2 to 6 percent slopes	51	68	50	66	17	25	2.2	3.2	3.7	5.3
Crofton-Nora silt loams, 6 to 12 percent slopes, eroded	34	54	35	55	14	21	1.8	2.6	3.0	4.4
Davis loam	75	91	56	84	22	32	3.1	4.3	5.2	7.2
Dempster silty clay loam	53	75	53	78	19	30	2.2	3.1	3.0	4.2
Egan-Shindler complex, 2 to 6 percent slopes	52	71	50	71	18	25	2.2	3.2	3.7	5.3
Egan-Shindler complex, 6 to 9 percent slopes	42	60	41	60	15	22	2.0	3.0	3.3	5.0
Enet loam, 0 to 2 percent slopes	46	56	46	64	18	28	1.8	2.6	2.9	4.5
Enet and Dempster soils, 2 to 6 percent slopes	46	62	46	65	16	25	1.5	2.4	2.5	4.0
Fluvaquents									4.0	5.2
Forney silty clay	56	75	48	68	18	28	2.5	3.3	4.0	5.3
Forney soils, overwash	60	78	50	71	19	29	2.7	3.5	4.4	5.6
Grable silt loam	50	70	40	60	15	25	2.0	2.8	3.2	4.5
Graceville silty clay loam	70	88	55	77	20	31	2.5	3.8	4.2	6.3
Haynie silt loam	63	84	56	74	18	29	2.5	3.5	4.2	6.0
Haynie silty clay loam	60	82	52	71	16	28	2.5	3.4	4.0	5.8
James silty clay	28	38			12	21	1.5	2.5	2.5	4.0
Kennebec silty clay loam	75	92	60	84	26	36	3.0	4.2	4.8	6.9
Lakeport silty clay loam	65	88	55	80	20	30	2.8	3.8	4.5	6.1
Lamo silty clay loam	65	85	52	73	21	30	2.9	4.1	4.8	6.9
Luton silty clay	47	64	36	63	18	29	2.0	3.3	3.3	5.5
McPaul silt loam	66	90	56	84	20	31	2.8	4.0	4.7	6.7
Modale silt loam	73	92	58	80	18	29	3.0	4.2	4.8	6.7
Moody silty clay loam, 0 to 2 percent slopes	72	90	53	80	25	37	2.8	4.0	4.7	6.7
Moody silty clay loam, 2 to 6 percent slopes	68	88	52	77	24	33	2.7	3.9	4.5	6.5
Moody-Nora silty clay loams, 6 to 10 percent slopes	54	76	44	66	19	26	2.3	3.2	3.7	5.2
Nora-Crofton silt loams, 20 to 50 percent slopes									2.7	4.0
Omadi silt loam	67	90	57	84	20	31	2.8	4.0	4.7	6.7
Onawa silty clay	54	75	41	57	20	28	2.6	3.6	4.3	6.0
Percival silty clay	50	70	38	58	18	28	2.3	3.1	3.6	5.0
Salix silty clay loam	70	90	61	83	25	36	3.0	4.3	5.0	7.2
Salmo silty clay loam, somewhat poorly drained	42	56	35	50	10	15	1.8	2.8	3.0	4.5
Sarpy loamy fine sand, 3 to 9 percent slopes									2.5	4.0
Sarpy silty clay overwash, 0 to 1 percent slopes	32	50	20	38	12	23	2.2	3.2	3.3	5.0
Sarpy soils, 0 to 3 percent slopes	30	47	19	36	12	21	2.0	3.0	3.1	4.6
Shindler clay loam, 9 to 15 percent slopes									2.5	4.5
Shindler clay loam, 15 to 30 percent slopes									2.1	4.0
Storla loam	44	59	32	48	11	19	1.2	2.1	2.0	3.5
Thurman fine sandy loam, 3 to 9 percent slopes	30	46	28	44	12	17	1.4	2.0	2.4	3.8
Wakonda-Worthing-Chancellor complex	49	69	49	69	16	25	2.0	3.1	3.5	5.1
Wentworth silty clay loam, 0 to 2 percent slopes	70	88	55	83	22	33	2.7	3.8	4.5	6.3
Wentworth silty clay loam, 2 to 6 percent slopes	62	83	54	81	21	31	2.6	3.7	4.3	6.2

See footnote at end of table.

TABLE 2.—*Predicted average annual yields per acre of principal dryfarmed crops and tame pasture*—Continued

Soil	Corn		Oats		Soybeans		Alfalfa		Pasture	
	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*AUM*[1]	*AUM*
Wentworth-Worthing silty clay loams	60	80	52	78	20	31	2.5	3.3	4.2	6.0
Whitewood silty clay loam	53	77	52	74	18	29	2.3	3.4	3.8	5.7
Worthing silty clay loam	45	63	49	67	15	24	2.1	3.0	3.4	5.0
Worthing-Chancellor silty clay loams	49	68	50	70	16	26	2.2	3.2	3.6	5.4

[1] AUM, *animal-unit-months*, is a term used to express the carrying capacity of pasture. It is the number of animal units, or 1,000 pounds of live weight, that can be grazed on an acre of pasture for a period of 30 days. This figure, multiplied by the number of acres, then divided by the number of months in the grazing season, is the number of animal units to be run without damage to the pasture.

growing conditions on soils having restricted drainage.

7. Adequately controlling weeds and insects by mechanical or chemical methods.
8. Keeping soil losses from soil blowing and water erosion within tolerable limits.
9. Replanting or renovating pastures when needed to maintain desirable vegetation.
10. Clipping pasture grasses as needed to help distribute grazing and stimulate plant growth.
11. Using proper grazing, which means delaying grazing until vegetation has a good start in the spring, never grazing too closely, rotating grazing, grazing or harvesting at the proper time, and allowing for fall regrowth before the first killing frost.

The predicted yields in table 2 are based on observations and comparisons made by farmers and by agriculturalists of State and Federal agencies. These predictions are long-term averages that take into account the years when the moisture supply is plentiful and years when it is not. They also take into account the probable loss caused by damaging hailstorms and late or early frosts.

Woodland and Windbreaks [4]

Union County has about 10,500 acres of native woodland. Most native trees and shrubs are on the breaks and bottom lands of the Big Sioux and Missouri Rivers, but stringers of native trees and shrubs are along the channels of the larger creeks and drainageways.

Most of the trees and shrubs are deciduous. The principal species on the bottom lands are American basswood, American elm, American plum, black walnut, black willow, boxelder, common chokecherry, eastern cottonwood, golden currant, green ash, hackberry, peachleaf willow, prickly ash, sandbar willow, silver maple, smooth sumac, Virginia creeper, wild grape, and several species of *Rosa* and *Symphoricarpos*. Except for eastern cottonwood and the willows, these same trees and shrubs as well as bur oak, eastern redcedar, honey locust, and red mulberry are in the wooded areas in the breaks of the Big Sioux and Missouri Rivers.

The early settlers used the trees and shrubs for building materials, fence posts, and fuel. Today, the native woodland is used on a limited basis for wood products and is valued mainly for livestock protection, wildlife habitat, recreation, watershed protection, and esthetic purposes. The acreage in native woodland on the bottom lands is steadily decreasing as the land is cleared for farming.

Windbreaks have been planted since the days of the early settlers. In most cases the early plantings were for the protection of the farmstead and livestock. Many farms still need this kind of protection, but there is also a growing interest in field windbreaks to help control soil blowing. Thousands of acres in Union County still need some form of protection from wind.

Windbreaks provide many economic and environmental benefits (*3*). They distribute and hold snow, preventing it from becoming a problem around the farmstead; they protect the home and livestock from cold and wintery winds and thereby reduce fuel and feed costs; they protect field crops, gardens, and orchards from strong damaging winds; they reduce evaporation of moisture; they provide a suitable habitat for many kinds of birds and other wildlife; they help control soil blowing; and they enhance the appearance of the rural home and its surroundings (fig. 16).

Before a windbreak is planted, some items to consider are the purpose of the planting, the suitability of the soils for windbreaks, the adaptability of trees and shrubs, and the location of the site. Establishment of a windbreak and continued growth of the trees depend on careful selection of plants, suitable preparation of the site, and adequate maintenance after planting. Grass and weeds must be eliminated before the trees are planted. Regrowth of the ground cover must be controlled for the entire life of the windbreak. Some replanting usually is necessary 1 or 2 years after the initial planting.

The soils of Union County are placed into 8 windbreak suitability groups. The growth response for adapted trees and shrubs generally is the same for all the soils in a group if good management practices are followed. The most critical factor in grouping soils into windbreak suitability groups is the amount and seasonal availability of soil moisture. Soils in groups 1 and 2 have water tables within the reach of trees, and some soils in group 10 are too wet for most trees and shrubs; however, the soils in all other groups generally lack a beneficial water table, and moisture conservation practices are needed for satisfactory tree growth.

Some of the windbreak groups have soils that have a range in slope and in texture of the surface layer. These two characteristics determine the degree of erosion and soil blowing hazards, which, in turn, affect the need for erosion control practices. Generally soils that are suitable for windbreaks but have slopes of more than 6 percent need erosion

[4] By DAVID L. HINTZ, forester, Soil Conservation Service.

Figure 16.—**Windbreak used to protect farmstead on Moody silty clay loam, 2 to 6 percent slopes.**

control practices such as contour planting and terracing. Special site preparation is usually needed where the soil blowing hazard is severe.

Table 3 lists the main trees and shrubs used in windbreak plantings and gives, by windbreak suitability groups, the estimated average height of the trees at 20 years of age.

In the following paragraphs the windbreak suitability groups in Union County are described. The numbers used to designate the groups are not consecutive because not all of the groups in the statewide system occur in the county. Also, not all of the soils in a given soil series are necessarily in the same windbreak group. To find the windbreak group of a particular soil, refer to the "Guide to Mapping Units" at the back of this survey.

WINDBREAK GROUP 1

This group consists of deep, nearly level to gently sloping, silty and loamy soils on bottom lands, on terraces, and in low areas on uplands. Most of these soils are moderately well drained, but some are somewhat poorly drained and one is well drained. These soils receive additional water from flooding or as runoff from adjacent soils. Some have a water table within reach of plant roots, but the wetness limitation is slight. The distribution of moisture is highly favorable for tree growth.

The soils in this group are well suited to windbreaks planted to protect farmsteads, feedlots, and fields. They are also well suited to plantings for recreation, wildlife habitat, and beautification.

WINDBREAK GROUP 2

This group consists of deep, somewhat poorly drained and poorly drained, level and nearly level, silty, loamy, and clayey soils. These soils have a water table that is high enough to limit the growth and development of root systems. The water table also limits the selection of trees and shrubs to those that tolerate wetness.

The soils in this group are well suited to windbreaks planted for the protection of farmsteads, feedlots, and fields. They are also well suited to plantings for recreation, wildlife habitat, and beautification.

WINDBREAK GROUP 3

This group consists of deep, well drained and moderately well drained, nearly level to undulating, silty and loamy soils on bottom lands and uplands. These soils have medium or high fertility and high available water capacity. Permeability is moderate in at least the upper part of all these soils. On the gently sloping to sloping soils in this group, the hazard of erosion is moderate to severe and the hazard of soil blowing is slight to moderate.

The soils in this group are well suited to windbreaks

TABLE 3.—*Estimated height of trees and shrubs at 20 years of age*

[Dashes indicate that the tree or shrub is not suited to soils in the specified group. Windbreak group 10 is not listed because the soils in that group are not suitable for windbreaks]

Trees and shrubs	Windbreak suitability group of soil						
	Group 1	Group 2	Group 3	Group 5	Group 6	Group 7	Group 8
Carolina poplar	35–40	30–35	—	—	—	—	—
Eastern cottonwood	35–40	32–36	—	—	—	—	—
Plains cottonwood	35–40	32–36	—	—	—	—	—
Northwest poplar	40–45	40–45	—	—	—	—	—
Robusta poplar	35–40	30–35	—	—	—	—	—
Chinkota elm	32–36	—	30–32	30–34	16–20	—	18–22
Dropmore elm	32–36	—	30–32	30–34	16–20	—	18–22
Golden willow	32–35	30–34	—	—	—	—	—
Siberian elm	32–36	—	30–32	30–34	16–20	—	18–22
Siouxland cottonwood	35–40	32–36	—	—	—	—	—
Austrian pine	24–30	20–22	22–26	—	—	—	—
Honeylocust	24–30	30–34	26–30	28–32	15–17	—	17–20
Ponderosa pine	24–30	20–22	22–26	20–24	13–15	14–16	14–16
Silver maple	30–35	30–35	25–30	—	—	—	—
White willow	32–35	30–34	—	—	—	—	—
Black Hills spruce	24–30	20–24	24–28	—	—	—	—
Blue spruce	24–30	20–24	24–28	—	—	—	—
Green ash	23–27	20–24	20–24	22–26	22–26	—	14–16
Scotch pine	24–30	20–22	22–26	—	—	—	—
White spruce	24–30	20–24	24–28	—	—	—	—
Bur oak	20–23	18–20	18–20	18–20	—	—	—
Hackberry	23–27	22–26	20–24	21–25	10–12	—	14–16
Laurel willow	20–25	20–25	—	—	—	—	—
Russian mulberry	20–23	18–20	18–20	—	—	—	—
Siberian larch	24–30	20–24	24–28	—	—	—	—
Boxelder	20–22	18–20	20–22	—	—	—	—
Harbin pear	16–18	14–16	15–17	15–17	11–12	—	7–9
Manchurian crabapple	18–20	16–18	15–17	17–19	12–14	—	—
Russian-olive	16–20	14–16	15–18	14–18	9–12	—	14–16
Siberian crabapple	18–20	16–18	15–17	17–19	12–14	—	—
Common chokecherry	12–14	9–11	9–12	9–11	—	—	—
Eastern redcedar	15–18	14–16	13–15	13–15	9–12	9–11	9–11
Manchurian apricot	12–14	12–14	12–15	11–13	—	—	—
Rocky Mountain juniper	15–18	14–16	13–15	13–15	9–12	9–11	9–11
Siberian apricot	12–14	12–14	12–15	11–13	—	—	—
Amur maple	10–12	10–11	9–10	—	—	—	—
Missouri River willow	10–15	10–15	—	—	—	—	—
Siberian peashrub	9–11	7–9	9–10	8–10	6–7	—	7–8
Silver buffaloberry	8–10	6–8	7–9	6–8	5–6	—	4–5
Tatarian honeysuckle	8–10	6–8	7–9	6–7	5–7	—	6–8
American plum	8–9	5–6	8–9	6–7	6–7	—	5–6
Late lilac	8–9	6–7	6–7	—	—	—	—
Lilac	7–8	5–6	6–7	6–7	4–5	—	5–6
Peking cotoneaster	6–7	5–6	5–6	6–7	4–5	—	5–6
Redosier dogwood	6–7	6–7	5–7	—	—	—	—
Golden currant	5–7	5–6	5–6	3–6	—	—	—
Nanking cherry[1]	5–7	6–8	5–6	6–8	—	—	—
Saskatoon serviceberry	5–6	5–6	—	—	—	—	—
Skunkbush sumac	5–7	5–6	5–6	5–7	—	—	—
Western sandcherry[2]	3–4	4–5	3–4	4–5	—	—	—

[1] Generally has a serious decline in vigor in 10 years or less.
[2] Generally has a serious decline in vigor after 5 years.

planted for the protection of farmsteads, feedlots, and fields. They are also well suited to plantings for recreation, beautification, and wildlife habitat. Planting on the contour and terracing help to control erosion and conserve moisture on the gently sloping to sloping or undulating soils.

WINDBREAK GROUP 5

Thurman fine sandy loam, 3 to 9 percent slopes, is the only soil in this group. It is a deep, somewhat excessively drained soil on uplands and terrace fronts. The surface layer is fine sandy loam, and the underlying material is loamy fine sand. This soil has medium fertility. Permeability is rapid, and the available water capacity is low or moderate. This soil is highly susceptible to soil blowing.

This soil is moderately well suited to windbreaks planted for the protection of farmsteads, feedlots, and fields. It is also well suited to plantings for recreation, wildlife habitat, and beautification. Planting cover crops and mulching with crop residue help control soil blowing while the windbreak is being established. Scalp planting is needed in areas where the surface layer is loamy fine sand.

WINDBREAK GROUP 6

This group consists of well drained and somewhat excessively drained, nearly level to gently sloping, silty and loamy soils that are moderately deep over fine sand or gravelly sand. These soils have medium or high fertility and low or moderate available water capacity. They are too droughty for most trees and shrubs because the underlying material is fine sand or gravelly sand.

These soils are poorly suited to windbreak plantings, but they are suited to plantings for wildlife habitat, recreation, and beautification if optimum growth is not a critical factor. Contour planting on the gently sloping soils helps to conserve moisture.

WINDBREAK GROUP 7

This group consists of deep, excessively drained soils on bottom lands. The surface layer ranges from fine sand to silty clay, and the underlying material is loamy fine sand and fine sand. Permeability is rapid, and the available water capacity is low. These soils are too droughty for trees and shrubs except in a few places that have a seasonal high water table. The hazard of soil blowing is very severe where the surface layer is sandy or where the underlying sandy material has been exposed by plowing.

Most of these soils are poorly suited to windbreaks and other types of woody plantings, but some areas have a seasonal water table within reach of tree roots. This site can be planted to suitable trees and shrubs if optimum growth is not a critical factor. Planting cover crops and mulching with crop residue help control soil blowing while the windbreak is being established. Scalp planting is needed in places where the surface layer is loamy fine sand or fine sand.

WINDBREAK GROUP 8

This group consists of deep, well drained, gently sloping to strongly sloping, silty soils on uplands. These soils are calcareous at or near the surface and have low fertility. The available water capacity is high. Runoff is medium to rapid, and the hazard of erosion is severe. These soils also are subject to soil blowing.

The soils in this group are poorly suited to windbreaks, but they can be planted to adapted trees and shrubs if optimum growth is not a critical factor. Planting on the contour and terracing help to control erosion and conserve moisture.

WINDBREAK GROUP 10

This group consists of soils that are too steep or too wet to plant trees with machinery. Some of the soils have low fertility. Some are too droughty or too wet for good survival and growth of trees and shrubs.

The soils in this group are not suited to windbreaks planted with machinery. They can be used for plantings for wildlife habitat, recreation, and beautification if the trees and shrubs are hand-planted and are given special care. Trees and shrubs that are tolerant of the soil problems at each site must be selected.

Wildlife [5]

Wildlife depends on the soils and is affected by soil management. The level of wildlife production depends on how well the habitat supplies food and cover in the form of both introduced and native plants. Most wildlife species depend on several kinds of soil to produce all the elements of habitat required.

Table 4 rates the 11 soil associations in Union County according to their suitability for producing wildlife habitat appropriate to 3 particular kinds of wildlife. The suitability of the major soils in each association is also rated and the extent of each soil is given. The kinds of wildlife are described in the following paragraphs.

Farmland wildlife includes animals that frequent croplands, pastures, meadows, and planted woodlands. Although these wildlife use other areas, such as naturally wooded lands and heavily vegetated marshlands, they are most closely associated with the cultivated areas. Examples of this kind of wildlife are pheasant, gray partridge, bobwhite quail, mourning dove, cottontail, jackrabbit, fox, raccoon, and whitetail deer.

Woodland wildlife includes animals that frequent large areas of naturally wooded lands. These lands are bordered by farmland, range, and pasture and in places include parts of these areas. The naturally wooded lands are the only part of the habitat considered in this rating. Planted woodlands are not included. Examples of woodland wildlife are whitetail deer, cottontail, tree squirrels, raccoon, coyote, turkey, ruffed grouse, thrushes, vireos, and scarlet tanagers.

Wetland wildlife includes animals that use natural wetlands (fig. 17), improved natural wetlands, or developed wetlands for all or part of their breeding habitat. Examples of this kind of wildlife are ducks, herons, shorebirds, coot, red winged blackbird, mink, muskrat, and beaver.

Rangeland wildlife is not evaluated because the acreage of range in Union County is so small and scattered that the potential for rangeland wildlife is poor.

The suitability ratings given in table 4 are defined as follows:

Good: Habitat can be easily established, constructed, improved, or maintained. There are few or no soil limitations to habitat management, and satisfactory results are generally assured.

Fair: Habitat can usually be established, constructed, improved, or maintained on these soils, but there are mod-

[5] By JOHN B. FARLEY, biologist, Soil Conservation Service.

TABLE 4.—*Suitability for wildlife habitat*

Soil associations	Extent of major soils	Suitability for— Farmland wildlife	Woodland wildlife	Wetland wildlife
	Percent			
1. Wentworth-Shindler-Worthing:				
Wentworth	50	Good	Very poor	Very poor.
Shindler	25	Fair	Very poor	Very poor.
Worthing	15	Fair	Very poor	Good.
2. Wakonda-Worthing-Chancellor:				
Wakonda	35	Fair	Very poor	Poor.
Worthing	25	Fair	Very poor	Good.
Chancellor	25	Good	Very poor	Fair.
3. Moody-Nora-Alcester:				
Moody	50	Good	Very poor	Very poor.
Nora	15	Good	Very poor	Very poor.
Alcester	15	Good	Poor	Very poor.
4. Crofton-Nora-Alcester:				
Crofton	45	Fair	Very poor	Very poor.
Nora	20	Good	Very poor	Very poor.
Alcester	20	Good	Poor	Very poor.
5. Graceville-Dempster:				
Graceville	45	Good	Poor	Very poor.
Dempster	35	Good	Very poor	Very poor.
6. Sarpy-Grable-Haynie:				
Sarpy	50	Poor	Poor	Very poor.
Grable	25	Fair	Fair	Very poor.
Haynie	15	Good	Good	Poor.
7. Calco-Kennebec:				
Calco	70	Poor	Fair	Good.
Kennebec	10	Good	Good	Poor.
8. Kennebec-Fluvaquents-Benclare:				
Kennebec	50	Good	Good	Poor.
Fluvaquents	15	Poor	Good	Fair.
Benclare	10	Good	Fair	Fair.
9. Albaton-Haynie-Onawa:				
Albaton	35	Fair	Fair	Good.
Haynie	25	Good	Good	Poor.
Onawa	20	Good	Good	Fair.
10. Forney-Luton:				
Forney	45	Fair	Poor	Fair.
Luton	25	Fair	Poor	Good.
11. Modale-Blyburg-Benclare:				
Modale	20	Good	Good	Poor.
Blyburg	15	Good	Fair	Very poor.
Benclare	15	Good	Fair	Fair.

erate soil limitations that affect habitat management or construction. A moderate intensity of management and fairly frequent attention may be required to insure satisfactory results.

Poor: Habitat can frequently be established, constructed, improved, or maintained on these soils, but there are rather severe soil limitations. Habitat establishment, management, or construction may be difficult, expensive, or require intensive effort. Good results cannot be insured.

Very poor: Naturally occurring habitat can sometimes be maintained with specific management, but it is generally not possible or feasible to establish, construct, or improve habitat on these soils.

Engineering

This section is useful to planning commissions, town and city managers, land developers, engineers, contractors, farmers, and others who need information about soils used as structural material or as foundation on which structures are built.

Among the soil properties highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table and slope. These properties, in various degrees and combinations, affect construction and maintenance of

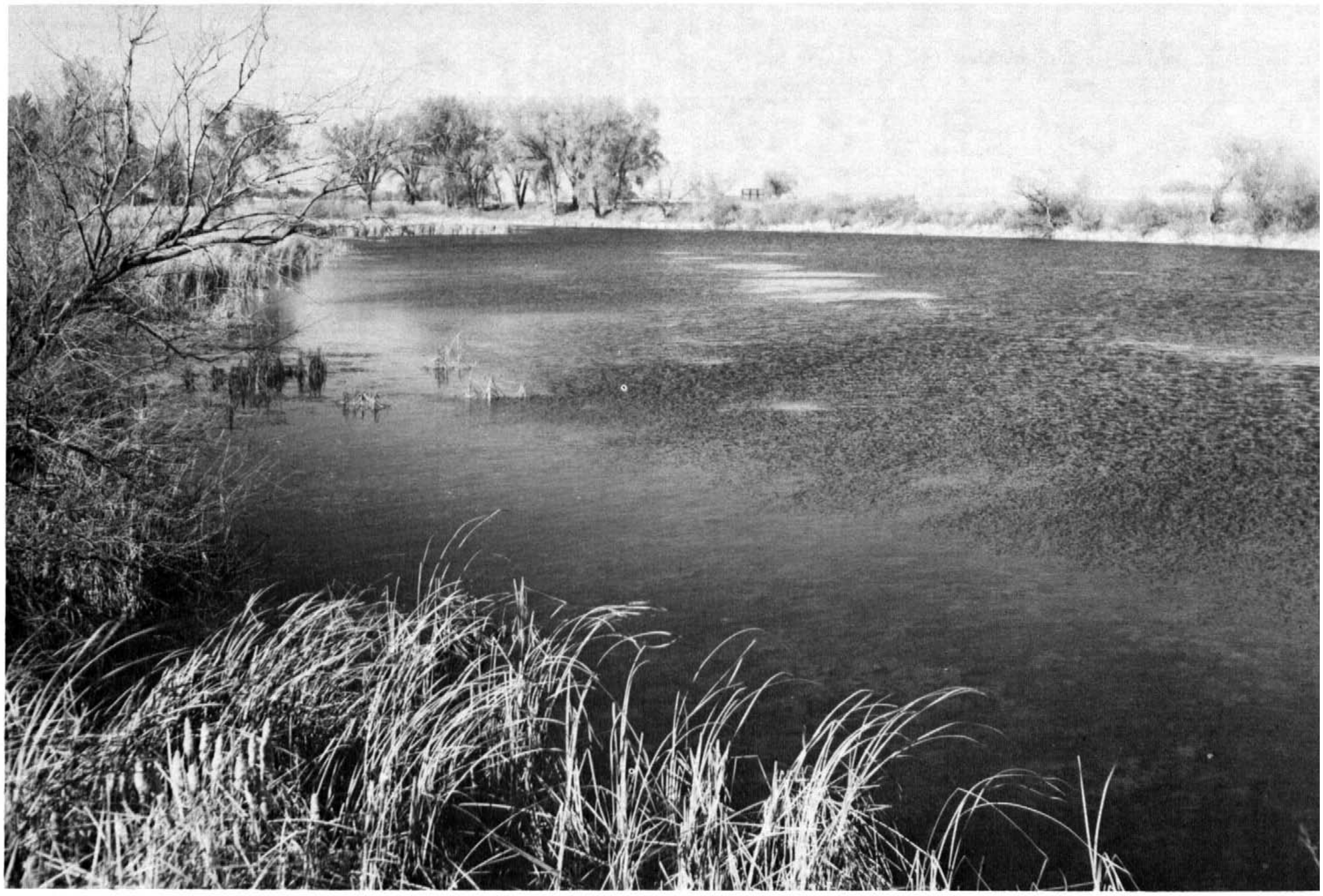

***Figure 17*.—This intermittent lake in the Albaton-Haynie-Onawa association provides habitat for wetland wildlife.**

roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the soils on which they are built for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables. Table 5 shows estimated soil properties significant in engineering, and table 6 gives interpretations for various engineering uses. Table 7 shows the results of engineering laboratory tests on soil samples. This information, along with the soil map and data in other parts of this publication, can be used to make interpretations in addition to those given in tables 5 and 6, and it also can be used to make useful maps.

This information, however, does not eliminate the need for further investigation at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally 6 feet. Also, inspection of sites, especially small ones, is needed because many delineated areas of a given soil can include small areas of other kinds of soil that have strongly contrasting properties and different suitability or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning to soil scientists. The Glossary defines many of the terms commonly used in soil science.

Engineering soil classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*2*) used by SCS engineers, the Department of Defense, and others, and the system adopted by the American Association

TABLE 5.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such column. The symbol > means more

Soil series and map symbols	Depth to seasonal water table	Depth from surface	Dominant USDA texture	Classification: Unified	Classification: AASHTO	Percentage less than 3 inches passing sieve— No. 4 (4.7 mm)	Percentage less than 3 inches passing sieve— No. 10 (2.0 mm)
	Feet	*Inches*					
Albaton: Ab, Ac, Ad	1–3	0–7	Silty clay	CH	A–7		100
		7–60	Silty clay	CH	A–7		100
Alcester: Ae	>5	0–34	Silt loam	ML or CL	A–6 or A–4		100
		34–60	Silty clay loam	CL	A–6 or A–7		100
Benclare: Bd, Be	[1] 3–6	0–16	Silty clay loam	CL, CH, or MH	A–7		100
		16–48	Silty clay	MH, CH, or ML	A–7		100
		48–60	Silty clay loam	CL or CH	A–7		100
Blencoe: Bf	[1] 1–3	0–24	Silty clay	CH or MH	A–7		100
		24–60	Silt loam	ML or CL	A–4 or A–6		100
Blyburg: Bg	>5	0–11	Silt loam	ML or CL	A–4 or A–6		
		11–60	Silt loam	ML or CL–ML	A–4		
Calco: Ca	[1] 0–3	0–47	Silty clay loam	CL, MH, CH, or ML	A–7		100
		47–60	Silty clay loam	CL, MH, or CH	A–7		100
Chancellor. Mapped only with Wakonda and Worthing soils.	[1] 2–5	0–17	Silty clay loam	CL or CH	A–6 or A–7		100
		17–33	Silty clay	CL or CH	A–7		100
		33–60	Silty clay loam	CL or CH	A–6 or A–7		100
*Crofton: CbE2, CbF, CnB, CnD2. For Nora part of CnB and CnD2, see Nora series.	>6	0–60	Silt loam	ML or CL	A–4, A–6, or A–7		100
Davis: Da	[1] >5	0–52	Loam	CL or ML	A–4 or A–6	100	90–100
		52–60	Loam	CL or ML	A–4 or A–6	100	95–100
Dempster: De	>5	0–17	Silty clay loam	CL	A–6 or A–7		100
		17–34	Silty clay loam	CL	A–6 or A–7		100
		34–60	Gravelly sand	SM, SW–SM, or SM–SC	A–1 or A–2	50–80	30–70
*Egan: EaB, EaC. For Shindler part of EaB and EaC, see Shindler series.	>6	0–13	Silty clay loam	CL or ML	A–6 or A–7		100
		13–30	Silty clay loam	CL or CH	A–6 or A–7	100	95–100
		30–60	Clay loam	CL or CH	A–6 or A–7	95–100	80–100
*Enet: EmA, EnB. For Dempster part of EnB, see Dempster series.	>5	0–20	Loam	ML or CL	A–4 or A–6	90–100	85–100
		20–33	Gravelly sandy loam	SM or SC	A–2 or A–4	60–100	60–95
		33–60	Gravelly loamy sand	GM, SM, SP-SM, or SC-SM	A–1 or A–2	40–80	30–70
Fluvaquents: Fa, Fb. Too variable to be rated.							
Forney: Fc, Fe	[1] 1–3	0–11	Silty clay	CH or MH	A–7		100
		11–60	Silty clay	CH or MH	A–7		100
Grable: Ga	2–5	0–7	Silt loam	CL or ML	A–4 or A–6		100
		7–15	Silt loam	CL or ML	A–4 or A–6		100
		15–27	Very fine sandy loam	ML, CL, or SM	A–4 or A–6		100
		27–60	Fine sand	SM or SP–SM	A–1, A–2, or A–3		100
Graceville: Gb	>5	0–36	Silty clay loam	CL or ML	A–7 or A–6	100	95–100
		36–52	Silty clay loam	CL or ML	A–7 or A–6	100	90–100
		52–60	Gravelly sand	SM, GM, SW-SM, or SM-SC	A–1 or A–2	40–80	30–70

See footnote at end of table.

significant in engineering

mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series as indicated in the first than; the symbol < means less than]

Percentage less than 3 inches passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
				In per hr	*In per in of soil*	*pH*	*Mmhos per cm*			
95–100	95–100	55–75	35–55	0.06–0.2	0.10–0.14	7.4–7.8	<2	High	High	Low.
95–100	95–100	60–85	40–60	0.02–0.2	0.08–0.12	7.4–8.4	<2	High	High	Low.
90–100	70–90	20–40	5–25	0.6–2.0	0.19–0.22	6.6–7.3	<2	Moderate	Moderate	Low.
90–100	70–100	30–50	10–30	0.6–2.0	0.17–0.20	6.6–7.8	<2	Moderate	Moderate	Low.
95–100	85–95	40–65	20–40	0.2–0.6	0.19–0.22	5.6–7.3	<2	High	Moderate	Moderate.
95–100	85–100	45–70	15–45	0.06–0.2	0.13–0.18	6.1–7.3	<2	High	Moderate	Moderate.
90–100	80–100	40–60	20–35	0.06–0.2	0.14–0.17	6.1–7.8	<2	High	High	Moderate.
95–100	95–100	50–65	20–35	<0.06	0.13–0.18	6.1–7.3	<2	High	High	Low.
95–100	85–100	30–40	5–20	0.6–2.0	0.17–0.20	6.6–8.4	<2	Moderate	High	Low.
100	90–100	20–40	5–20	0.6–2.0	0.19–0.22	6.6–7.8	<2	Low	Low	Low.
100	70–100	20–35	5–10	0.6–2.0	0.17–0.20	7.4–8.4	<2	Low	Low	Low.
95–100	85–100	40–60	15–35	0.2–0.6	0.19–0.22	7.4–8.4	<2	High	High	Low.
90–100	80–100	40–60	20–35	0.2–0.6	0.17–0.20	7.9–8.4	<2	High	High	Low.
95–100	85–100	35–55	15–35	0.06–0.2	0.19–0.22	6.1–7.3	<2	High	High	Low.
95–100	95–100	40–60	20–40	0.06–0.2	0.13–0.18	6.6–7.3	<2	High	High	Low.
95–100	85–100	35–55	15–35	0.06–0.6	0.14–0.17	6.6–7.8	<2	High	High	Moderate.
95–100	95–100	30–45	5–20	0.6–2.0	0.17–0.20	7.4–8.4	<2	Low	Moderate	Low.
80–100	50–95	25–40	5–20	0.6–2.0	0.18–0.20	6.1–7.3	<2	Moderate	Moderate	Low.
85–100	55–90	25–40	5–20	0.6–2.0	0.16–0.18	6.6–7.8	<2	Moderate	Moderate	Low.
90–100	70–90	30–45	10–25	0.6–2.0	0.19–0.22	5.6–6.6	<2	Moderate	Moderate	Low.
95–100	85–95	30–45	10–25	0.6–2.0	0.17–0.20	5.6–7.3	<2	Moderate	Moderate	Low.
20–50	5–30	<25	[2] NP–5	6.0–20.0	0.03–0.06	5.6–7.8	<2	Low	Moderate	Low.
95–100	85–100	35–50	10–25	0.6–2.0	0.19–0.22	6.1–7.3	<2	Moderate	Moderate	Low.
90–100	80–100	35–55	15–35	0.6–2.0	0.17–0.20	6.6–7.8	<2	Moderate	High	Low.
70–100	60–85	30–55	10–35	0.2–0.6	0.17–0.20	7.4–8.4	<2	Moderate	High	Moderate.
70–95	50–80	25–40	5–20	0.6–2.0	0.18–0.20	6.1–7.3	<2	Low	Low	Low.
50–95	30–50	20–30	5–10	2.0–6.0	0.09–0.13	6.6–7.3	<2	Low	Moderate	Low.
20–50	5–35	<20	NP–5	6.0–20.0	0.03–0.06	7.4–8.4	<2	Low	Moderate	Low.
95–100	95–100	60–85	25–50	0.06–0.2	0.13–0.18	6.1–7.3	<2	High	High	Low.
95–100	95–100	60–85	25–55	<0.06	0.08–0.12	6.1–7.3	<2	High	High	Low.
90–100	75–95	20–40	8–20	0.6–2.0	0.19–0.22	7.4–8.4	<2	Moderate	Moderate	Low.
90–100	75–95	20–40	8–20	0.6–2.0	0.17–0.20	7.4–8.4	<2	Moderate	Moderate	Low.
80–90	40–60	15–30	3–15	2.0–6.0	0.15–0.17	7.4–8.4	<2	Low	Moderate	Low.
40–60	5–30	<20	NP–5	6.0–20.0	0.06–0.08	7.4–8.4	<2	Low	Moderate	Low.
80–95	70–90	35–50	10–30	0.6–2.0	0.19–0.22	5.6–6.5	<2	Moderate	Moderate	Low.
80–90	75–85	35–50	10–30	0.6–2.0	0.17–0.20	6.1–7.3	<2	Moderate	Moderate	Low.
20–50	5–30	<25	NP–5	6.0–20.0	0.03–0.06	6.6–7.8	<2	Low	Moderate	Low.

TABLE 5.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal water table	Depth from surface	Dominant USDA texture	Classification		Percentage less than 3 inches passing sieve—	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*					
Haynie: Ha, Hb	[1] 4–8	0–21	Silt loam	ML or CL	A–6 or A–7		100
		21–60	Very fine sandy loam	ML or CL	A–4 or A–6		100
James: Ja	[1] 0–2	0–30	Silty clay	CL, CH, or MH	A–7		100
		30–60	Silty clay	CL, CH, or MH	A–7		100
Kennebec: Ka	[1] 3–5	0–50	Silty clay loam	CL	A–6 or A–7		100
		50–60	Loam	CL or ML	A–4 or A–6	100	90–100
Lakeport: La	2–4	0–15	Silty clay loam	CL, CH, or MH	A–7		100
		15–42	Silty clay	CH or MH	A–7		100
		42–60	Stratified silty clay loam and silty clay.	CL or CH	A–7		100
Lamo: Lb	[1] 2–5	0–60	Silty clay loam	CL, MH, or CH	A–7		100
Luton: Ld	[1] 1–3	0–30	Silty clay	CH or MH	A–7		100
		30–60	Silty clay	CH or MH	A–7		100
McPaul: Ma	[1] 3–5	0–41	Silt loam	ML or CL	A–4 or A–6		100
		41–60	Silty clay loam	CL, CH, or MH	A–6 or A–7		100
Modale: Mb	[1] 1–3	0–11	Silt loam	CL	A–6		100
		11–24	Very fine sandy loam	ML or CL	A–4 or A–6		100
		24–60	Silty clay	CH or MH	A–7		100
*Moody: McA, McB, MdC. For Nora part of MdC, see Nora series.	>5	0–12	Silty clay loam	CL	A–6 or A–7		100
		12–33	Silty clay loam	CL or CH	A–6 or A–7		100
		33–60	Silt loam	ML or CL	A–4, A–6, or A–7		100
*Nora: NeF. For Crofton part, see Crofton series.	>5	0–8	Silty clay loam	CL or ML	A–6 or A–7		100
		8–20	Silt loam	CL	A–6 or A–7		100
		20–60	Silt loam	ML or CL	A–4, A–6, or A–7		100
Omadi: Oa	>5	0–11	Silt loam	CL	A–6		
		11–60	Silt loam	ML or CL	A–6 or A–7		
Onawa: Ob	[1] 2–4	0–7	Silty clay	CH or MH	A–7		100
		7–25	Silty clay	CH or MH	A–7		100
		25–60	Silt loam	CL or ML	A–4, A–6, or A–7		100
Percival: Pa	[1] 1–3	0–7	Silty clay	CH or MH	A–7		100
		7–25	Silty clay	CH or MH	A–7		100
		25–60	Stratified fine sand and loamy fine sand.	SM or SP-SM	A–2 or A–3		100
Salix: Sa	[1] 3–5	0–17	Silty clay loam	ML, CL, MH, or CH	A–7		100
		17–30	Silty clay loam	CL or ML	A–6 or A–7		100
		30–60	Silt loam	ML or CL	A–6 or A–4		100
Salmo: Sb	[1] 2–3	0–8	Silty clay loam	CL or ML	A–4, A–6, or A–7		100
		8–33	Silt loam	CL	A–6 or A–7		100
		33–60	Silty clay loam and silt loam.	CL	A–6 or A–7		100
Sarpy: ScB, SdA, SeA	>5	0–60	Stratified loamy fine sand and fine sand.	SM or SP	A–2 or A–3		100
Shindler: ShD, ShE	>5	0–18	Clay loam	CL or ML	A–6 or A–7	95–100	95–100
		18–60	Clay loam	CL	A–6 or A–7	95–100	95–100

See footnote at end of table.

significant in engineering—Continued

Percentage less than 3 inches passing sieve—Continued		Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity	
No. 40 (0.42 mm)	No. 200 (0.074 mm)								Uncoated steel	Concrete
				In per hr	*In per in of soil*	*pH*	*Mmhos per cm*			
85–100	70–100	30–50	10–25	0.6–2.0	0.17–0.20	7.4–8.4	<2	Low	Moderate	Low.
85–100	60–100	15–30	5–20	0.6–2.0	0.15–0.17	7.4–8.4	<2	Low	Moderate	Low.
90–100	85–95	45–80	20–50	0.06–0.2	0.10–0.15	7.4–9.0	4–20	High	High	High.
90–100	85–95	45–80	20–50	0.06–0.2	0.08–0.13	7.8–9.0	4–8	High	High	High.
95–100	90–100	35–50	15–25	0.6–2.0	0.19–0.22	6.1–7.3	<2	Moderate	Moderate	Low.
70–95	55–80	25–35	5–20	0.6–20.0	0.18–0.20	6.1–7.3	<2	Low or moderate.	Moderate	Low.
95–100	95–100	40–60	15–30	0.2–2.0	0.19–0.22	6.1–7.3	<2	High	High	Low.
95–100	85–100	50–70	20–40	0.2–0.6	0.12–0.16	6.1–7.8	<2	High	High	Low.
95–100	85–100	40–55	15–40	0.2–0.6	0.14–0.17	7.4–8.4	<2	High	High	Low.
95–100	85–95	40–60	20–35	0.2–0.6	0.19–0.22	7.4–8.4	<2	High	High	Low.
95–100	95–100	50–80	20–50	<0.06	0.10–0.14	6.6–7.3	<2	High	High	Low.
95–100	95–100	50–80	20–50	<0.06	0.08–0.12	6.6–8.4	<2	High	High	Low.
85–100	95–100	30–40	5–15	0.6–2.0	0.17–0.20	7.4–8.4	<2	Moderate	High	Low.
90–100	70–95	25–55	10–25	0.6–2.0	0.19–0.22	6.1–8.4	<2	Moderate	High	Low.
95–100	70–90	25–40	10–20	0.6–2.0	0.17–0.20	7.4–8.4	<2	Moderate	Moderate	Low.
85–95	60–90	15–30	5–15	0.6–2.0	0.15–0.17	7.4–8.4	<2	Moderate	Moderate	Low.
95–100	95–100	65–85	25–60	<0.06	0.08–0.12	7.4–8.4	<2	High	High	Low.
95–100	90–100	35–60	10–30	0.6–2.0	0.19–0.22	6.1–7.3	<2	Moderate	Moderate	Low.
95–100	85–100	30–55	10–35	0.6–2.0	0.17–0.20	6.1–7.3	<2	Moderate	Moderate	Low.
95–100	85–100	25–45	5–25	0.6–2.0	0.17–0.20	7.4–8.4	<2	Moderate	Moderate	Low.
95–100	95–100	35–50	10–30	0.6–2.0	0.19–0.22	6.1–7.3	<2	Moderate	Low	Low.
90–100	75–100	30–45	10–30	0.6–2.0	0.17–0.20	6.6–7.8	<2	Moderate	Low	Low.
90–100	70–100	25–45	5–25	0.6–2.0	0.17–0.20	7.4–8.4	<2	Moderate	Low	Low.
100	90–100	25–40	10–20	0.6–2.0	0.19–0.22	6.6–7.8	<2	Moderate	Low	Low.
100	90–100	25–50	10–20	0.6–2.0	0.17–0.20	7.4–8.4	<2	Moderate	Low	Low.
95–100	95–100	50–85	25–60	0.06–0.2	0.10–0.14	7.4–8.4	<2	High	High	Low.
95–100	95–100	50–85	25–60	0.06–0.2	0.08–0.12	7.4–8.4	<2	High	High	Low.
95–100	85–100	30–50	5–30	0.6–2.0	0.17–0.20	7.4–8.4	<2	Moderate	High	Low.
95–100	95–100	60–85	30–60	0.06–0.2	0.10–0.14	7.4–7.8	<2	High	High	Low.
95–100	95–100	60–85	30–60	0.06–0.2	0.08–0.12	7.4–8.4	<2	High	High	Low.
80–95	5–30	<25	NP–5	6.0–20.0	0.06–0.08	7.4–8.4	<2	Low	High	Low.
95–100	95–100	45–65	15–35	0.6–2.0	0.19–0.22	6.1–7.3	<2	Moderate or high.	High	Low.
95–100	95–100	35–50	10–30	0.6–2.0	0.17–0.20	6.1–7.3	<2	Moderate or high.	High	Low.
95–100	90–100	25–40	5–25	0.6–2.0	0.17–0.20	7.4–8.4	<2	Moderate	High	Low.
90–100	70–95	30–45	5–25	0.2–0.6	0.16–0.19	7.4–8.4	4–16	Moderate	High	High.
95–100	85–95	30–45	10–25	0.2–0.6	0.16–0.19	7.4–8.4	4–16	Moderate	High	High.
95–100	85–95	35–50	10–25	0.2–0.6	0.14–0.17	7.4–8.4	4–8	Moderate	High	High.
60–80	0–35	<25	NP	6.0–20.0	0.06–0.08	7.4–8.4	<2	Low	Low	Low.
85–100	65–80	35–45	10–30	0.6–2.0	0.19–0.22	6.6–7.8	<2	Moderate	High	Low.
85–100	65–85	35–50	15–30	0.2–0.6	0.17–0.20	7.4–8.4	<2	Moderate	High	Moderate.

TABLE 5.—*Estimated soil properties*

Soil series and map symbols	Depth to seasonal water table	Depth from surface	Dominant USDA texture	Classification		Percentage less than 3 inches passing sieve—	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Feet	*Inches*					
Storla: St	2–3	0–14	Loam	ML or CL	A–4 or A–6	100	95–100
		14–31	Loam	ML, CL, or SC	A–4 or A–6	95–100	85–100
		31–60	Gravelly sand	SM, SM–SC, SP–SM, or SW–SM	A–1 or A–2	60–90	45–70
Thurman: TaB	>5	0–10	Fine sandy loam	SC, CL, or SC–SM	A–4	----------	100
		10–50	Loamy fine sand	SM or SP–SM	A–2 or A–3	----------	100
		50–60	Fine sandy loam	SC or SC–SM	A–2 or A–4	----------	100
*Wakonda: Wa For Chancellor part, see Chancellor series; for Worthing part, see Worthing series.	2–5	0–10	Silt loam	ML or CL	A–4 or A–6	----------	100
		10–45	Silt loam	ML or CL	A–4 or A–6	----------	100
		45–60	Silt loam	CL	A–4, A–6, or A–7	----------	100
*Wentworth: WbA, WbB, Wc For Worthing part of Wc, see Worthing series.	>5	0–9	Silty clay loam	CL	A–6 or A–7	100	95–100
		9–50	Silty clay loam	CL or CH	A–6 or A–7	100	95–100
		50–60	Stratified loam and silt loam.	CL or ML	A–4, A–6, or A–7	100	95–100
Whitewood: Wh	[1] 1–5	0–30	Silty clay loam	CL, CH, or MH	A–6 or A–7	----------	100
		30–60	Silty clay loam	CL, CH, or MH	A–6 or A–7	----------	100
*Worthing: Wo, Ws For Chancellor part of Ws, see Chancellor series.	[1] 1–5	0–19	Silty clay loam	CL	A–7	----------	100
		19–45	Silty clay	CH	A–7	----------	100
		45–60	Silty clay loam	CL or CH	A–7	100	95–100

[1] Subject to flooding.

of State Highway and Transportation Officials (AASHTO) (*1*).

In the Unified system, soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes. These are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes, for example, CL–ML.

The AASHTO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system a soil is placed in one of seven basic groups ranging from A–1 to A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHTO classification for tested soils, with group index numbers in parentheses, is shown in tables 7 and 8; the estimated classification, without group index numbers, is given in table 5 for all soils mapped in the survey area.

Soil properties significant in engineering

Several estimated soil properties significant in engineering are given in table 5. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the column headings in table 5.

Depth to seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in table 5 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used are defined in the Glossary.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As

significant in engineering—Continued

Percentage less than 3 inches passing sieve—Continued: No. 40 (0.42 mm)	Percentage less than 3 inches passing sieve—Continued: No. 200 (0.074 mm)	Liquid limit	Plasticity index	Permeability	Available water capacity	Reaction	Salinity	Shrink-swell potential	Corrosivity: Uncoated steel	Corrosivity: Concrete
				In per hr	*In per in of soil*	*pH*	*Mmhos per cm*			
75–95	50–80	30–40	5–20	0.6–2.0	0.18–0.20	7.4–8.4	<2	Moderate	High	Moderate.
60–95	35–80	25–40	5–20	0.6–2.0	0.13–0.15	7.4–8.4	<2	Moderate	High	Moderate.
20–60	5–30	<25	NP–5	6.0–20.0	0.03–0.06	7.4–8.4	<2	Low	High	Moderate.
70–85	40–55	10–25	5–10	2.0–6.0	0.14–0.17	6.1–7.3	<2	Low	Low	Low.
85–100	5–25	<20	NP–5	6.0–20.0	0.08–0.10	6.6–7.8	<2	Low	Low	Low.
70–90	30–50	10–25	5–10	2.0–6.0	0.12–0.15	6.6–7.8	<2	Low	Low	Low.
90–100	85–100	25–40	5–25	0.6–2.0	0.19–0.22	7.4–8.4	2–4	Moderate	High	Low.
90–100	85–100	25–40	5–25	0.6–2.0	0.14–0.17	7.4–8.4	4–8	Moderate	High	Moderate.
85–95	60–90	30–45	10–25	0.6–2.0	0.17–0.20	7.4–8.4	4–8	Moderate	High	Moderate.
95–100	70–90	35–50	15–30	0.6–2.0	0.19–0.22	6.1–7.3	<2	Moderate	Moderate	Low.
85–100	75–100	35–55	15–30	0.6–2.0	0.17–0.20	6.1–7.8	<2	Moderate	Moderate	Low.
85–100	60–100	30–50	5–30	0.6–2.0	0.17–0.20	7.4–8.4	<2	Moderate	High	Low.
95–100	80–95	35–55	15–30	0.2–2.0	0.19–0.22	6.1–7.8	<2	Moderate	Moderate	Low.
95–100	80–95	35–55	15–30	0.2–0.6	0.17–0.20	6.6–7.8	<2	Moderate	High	Low.
95–100	85–95	40–50	20–30	0.2–0.6	0.19–0.22	6.1–6.6	<2	High	Moderate	Low.
95–100	85–100	50–70	25–40	0.06–0.2	0.13–0.18	6.1–7.3	<2	High	High	Low.
90–100	70–95	40–60	20–35	0.06–0.2	0.14–0.17	7.4–8.4	<2	High	High	Low.

[2] NP means nonplastic.

the moisture content of a clayey soil is increased from a dry state, the material changes from semisolid to plastic. If the moisture content is further increased, the material changes from plastic to liquid. The *plastic limit* is the moisture content at which the soil material changes from semisolid to plastic; the *liquid limit*, from plastic to liquid. The *plasticity index* is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. The liquid limit and the plasticity index are estimated in table 5, but in tables 7 and 8 the data on both are based on tests of soil samples.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 5 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Salinity refers to the amount of soluble salts in the soil. It is expressed as the electrical conductivity of the saturation extract, in millimhos per centimeter at 25° C. Salinity affects the suitability of a soil for crop production, its stability when used as construction material, and its corrosiveness to metals and concrete.

Shrink-swell potential is the relative change in volume of soil material to be expected with changes in moisture content, that is, the extent to which the soil shrinks as it dries or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to the maintenance of structures built in, on, or with material having this rating.

Corrosivity pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. Rate of corrosion of uncoated steel is related to soil properties such as drainage, texture, total acidity, and electrical conductivity of the soil material. Corrosivity for concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. A corrosivity rating of *low* means that there is a low probability of soil-induced corrosion damage. A rating of *high* means that there is a high probability of damage, so that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

TABLE 6.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Roads and streets
Albaton: Ab, Ac, Ad.	Severe: slow to very slow permeability; seasonal high water table. [1]	Severe: subject to flooding. Slight if protected from flooding.	Severe: poorly drained; silty clay texture.	Severe: poorly drained; high shrink-swell potential.	Severe: poorly drained; silty clay texture.	Severe: poorly drained; high shrink-swell potential.
Alcester: Ae	Moderate: moderate permeability.	Moderate: moderate permeability; gently sloping.	Slight	Moderate: moderate shrink-swell potential.	Moderate: silty clay loam substratum.	Severe: high susceptibility to frost action.
Benclare: Bd, Be	Severe: slow permeability; seasonal high water table. [1]	Severe: subject to flooding. Slight if protected from flooding.	Severe: silty clay subsoil; subject to flooding.	Severe: high shrink-swell potential; subject to flooding.	Severe: silty clay subsoil; seasonal high water table.	Severe: high shrink-swell potential; low shear strength.
Blencoe: Bf	Severe: very slow permeability; seasonal high water table. [1]	Severe: seasonal high water table; subject to flooding.	Severe: somewhat poorly drained; silty clay texture.	Severe: seasonal high water table; high shrink-swell potential.	Severe: seasonal high water table; high shrink-swell potential.	Severe: high shrink-swell potential; subject to flooding.
Blyburg: Bg	Moderate: moderate permeability. [1]	Moderate: moderate permeability.	Moderate: wall unstable in places.	Moderate: low shear strength.	Slight	Moderate: low to medium shear strength; moderate susceptibility to frost action.
Calco: Ca	Severe: moderately slow permeability; seasonal high water table; subject to flooding.	Severe: seasonal high water table; subject to flooding.	Severe: poorly drained; seasonal high water table; subject to flooding.	Severe: subject to flooding; seasonal high water table; high shrink-swell potential.	Severe: poorly drained; subject to flooding; seasonal high water table.	Severe: subject to flooding; poorly drained; high shrink-swell potential.
Chancellor. Mapped only with Wakonda and Worthing soils.	Severe: slow permeability; seasonal high water table; subject to flooding.	Slight	Severe: somewhat poorly drained; subject to flooding; silty clay subsoil.	Severe: somewhat poorly drained; subject to flooding; high shrink-swell potential.	Severe: seasonal high water table; subject to flooding.	Severe: high shrink-swell potential; subject to flooding.
*Crofton: CbE2, CbF, CnB, CnD2. For Nora part of CnB and CnD2, see Nora series.	Slight if slopes are less than 8 percent, moderate if 8 to 15, severe if more than 15.	Moderate if slopes are less than 7 percent; moderate permeability. Severe if slopes are more than 7 percent.	Slight if slopes are less than 8 percent, moderate if 8 to 15, severe if more than 15.	Slight if slopes are less than 8 percent, moderate if 8 to 15, severe if more than 15.	Slight if slopes are less than 15 cent, moderate if 15 to 25, severe if more than 25.	Moderate if slopes are less than 15 percent; moderate frost action potential. Severe if slopes are more than 15 percent.

See footnote at end of table.

interpretations of the soils

mapping units may have different properties and limitations, and for this reason it is necessary to refer to other series as indicated in the first column]

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions
Poor: poorly drained; high shrink-swell potential.	Unsuited	Poor: poorly drained; silty clay texture.	Level; seasonal high water table; very slow to slow permeability.	High compressibility; medium to low shear strength; fair to poor compaction characteristics.	Slow to very slow permeability; outlets commonly not available.	Poorly drained; very slow intake rate; level.	Level; silty clay texture.
Poor: high susceptibility to frost action.	Unsuited	Good	Moderate permeability; gently sloping.	Fair to poor stability and compaction characteristics; medium to low shear strength.	Moderately well drained.	Gently sloping; high available water capacity.	Gently sloping; moderate permeability.
Poor: high shrink-swell potential; low shear strength.	Unsuited	Fair: silty clay loam texture.	Level; seasonal high water table; slow permeability.	High shrink-swell potential; low shear strength; high compressibility.	Slow permeability.	Subject to flooding; slow intake rate.	Not needed.
Poor: high shrink-swell potential; low shear strength.	Unsuited	Poor: silty clay texture.	Level; seasonal high water table; very slow permeability in upper 2 feet.	Low shear strength; high shrink-swell potential; high compressibility.	Moderate permeability below a depth of 2 feet; outlets not available in places.	Somewhat poorly drained; very slow intake rate; moderate permeability below a depth of 2 feet.	Not needed.
Fair: low to medium shear strength.	Unsuited	Good	Nearly level; moderate permeability.	Low to medium shear strength and compressibility; high susceptibility to piping; fair to poor compaction characteristics.	Well drained	High available water capacity; moderate intake rate.	Not needed.
Poor: high shrink-swell potential; low shear strength.	Unsuited	Poor: poorly drained.	Level; seasonal high water table; moderately slow permeability; thin layers of sand in substratum in places.	High compressibility; low shear strength; poor compaction characteristics.	Moderately slow permeability; subject to flooding; outlets commonly not available.	Poorly drained; subject to flooding.	Not needed.
Poor: high shrink-swell potential; low shear strength.	Unsuited	Fair: silty clay loam texture.	Seasonal high water table; slow permeability.	Fair to poor stability and compaction characteristics; high shrink-swell potential; low shear strength.	Slow permeability; poor outlets.	Subject to flooding; slow intake rate; high available water capacity.	Not needed.
Fair if slopes are less than 25 percent; CL or ML material; moderate frost action potential. Poor if slopes are more than 25 percent.	Unsuited	Fair: thin surface layer; low fertility; excess lime.	Moderate permeability; gently sloping to very steep.	Fair to poor bearing capacity; subject to piping; difficult to compact; erodes easily.	Well drained	High available water capacity; moderate intake rate; erodes easily; gently sloping to very steep.	Erodes easily; gently sloping to very steep; moderate permeability.

TABLE 6.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Roads and streets
Davis: Da	Severe: subject to flooding.	Moderate: moderate permeability.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Dempster: De	Slight [1]	Severe: rapid permeability in substratum. [1]	Moderate: gravelly sand at a depth of 34 inches.	Slight	Severe: rapid permeability below a depth of 34 inches. [1]	Moderate: moderate shrink-swell potential in upper 34 inches.
*Egan: EaB, EaC. For Shindler part, see Shindler series.	Severe: moderately slow permeability in substratum.	Moderate if slopes are less than 7 percent, severe if more than 7.	Moderate: clay loam texture below a depth of 30 inches.	Moderate: moderate shrink-swell potential.	Moderate: silty clay loam and clay loam textures.	Severe: high susceptibility to frost action.
*Enet: EmA, EnB. For Dempster part of EnB, see Dempster series.	Slight [1]	Severe: rapid permeability in substratum. [1]	Severe: vertical banks slough.	Slight	Severe: rapid permeability in substratum. [1]	Moderate: medium to low shear strength; moderate susceptibility to frost action.
Fluvaquents: Fa, Fb. No interpretations. Severe limitations for most uses.						
Forney: Fc, Fe	Severe: very slow permeability; seasonal high water table.	Severe: subject to flooding. Slight if protected from flooding.	Severe: poorly drained; silty clay texture; subject to flooding in places.	Severe: seasonal high water table; high shrink-swell potential; subject to flooding.	Severe: poorly drained; silty clay texture.	Severe: poorly drained; high shrink-swell potential.
Grable: Ga	Moderate: seasonal high water table. [1]	Severe: rapid permeability in substratum; seasonal high water table. [1]	Severe: fine sand below a depth of 27 inches; seasonal high water table.	Moderate: seasonal high water table.	Severe: seasonal high water table; rapid permeability in substratum. [1]	Severe: high susceptibility to frost action.
Graceville: Gb	Moderate: moderate permeability. [1]	Moderate: moderate permeability; severe if basin floor is below a depth of 4 feet. [1]	Moderate: moderately well drained; gravelly sand below a depth of 52 inches.	Moderate: moderate shrink-swell potential.	Severe: rapid permeability below a depth of 52 inches. [1]	Severe: high susceptibility to frost action.

See footnote at end of table.

interpretations of the soil—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions
Fair: low shear strength; moderate shrink-swell potential.	Unsuited	Good	Moderate permeability.	Low shear strength; fair to poor stability and compaction characteristics.	Moderately well drained.	Subject to flooding; high available water capacity; moderately slow intake rate.	Nearly level; generally not applicable.
Fair in upper part: moderate shrink-swell potential. Good below a depth of 34 inches.	Good to fair: excess fines in places.	Fair: silty clay loam texture.	Rapid permeability below a depth of 34 inches.	Fair to good stability and compaction characteristics; medium to low shear strength.	Well drained	Moderate available water capacity; moderate intake rate.	Moderately deep to gravelly sand; nearly level.
Poor: low shear strength; high susceptibility to frost action.	Unsuited	Fair: silty clay loam texture.	Moderately slow permeability in substratum; gently sloping to sloping.	Fair to good stability and compaction characteristics; low shear strength; moderate shrink-swell potential.	Well drained	Slow intake rate; high available water capacity; slopes of 2 to 9 percent.	Short irregular slopes in places; moderately slow permeability in substratum.
Good below a depth of 20 inches.	Good to fair: excess fines in places.	Good	Rapid permeability in substratum.	Medium to low shear strength; fair to good compaction characteristics; subject to piping.	Well drained	Low to moderate available water capacity; moderate intake rate; nearly level to gently sloping.	Short irregular slopes in places; moderately deep to sandy material.
Poor: poorly drained; high shrink-swell potential.	Unsuited	Poor: silty clay texture; poorly drained.	Level; very slow permeability; seasonal high water table.	High compressibility; fair to poor compaction characteristics; medium to low shear strength.	Very slow permeability; level.	Poorly drained; very slow intake rate.	Not needed.
Good below a depth of 15 inches.	Fair to poor for sand: stratified with fines in places. Unsuited for gravel.	Good	Rapid permeability in substratum; nearly level; seasonal high water table.	Fair to poor compaction characteristics in upper part and fair to good in lower part; medium shear strength; medium to high susceptibility to piping.	Somewhat excessively drained.	Moderate available water capacity; moderate intake rate.	Not needed.
Poor: high susceptibility to frost action.	Fair to good below a depth of 52 inches; excess fines in places.	Fair: silty clay loam texture.	Rapid permeability below a depth of 52 inches; nearly level.	Fair to good stability and compaction characteristics; medium to low shear strength.	Moderately well drained; moderate permeability.	High available water capacity; moderately slow intake rate; good drainage in substratum.	Not needed.

TABLE 6.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Roads and streets
Haynie: Ha, Hb	Severe: subject to flooding. Slight if protected from flooding.	Severe: subject to flooding. Moderate if protected from flooding; moderate permeability.	Severe: subject to flooding. Slight if protected from flooding; sloughing in places.	Severe: subject to flooding; seasonal high water table in places. Slight if protected from flooding.	Severe: subject to flooding. Silght if protected from flooding; seasonal high water table in places.	Severe: subject to flooding. Moderate if protected from flooding; moderate susceptibility to frost action.
James: Ja	Severe: subject to flooding; slow permeability; high water table.	Severe: subject to flooding; high water table.	Severe: subject to flooding; high water table; silty clay texture.	Severe: subject to flooding; high shrink-swell potential.	Severe: subject to flooding; seasonal high water table.	Severe: high susceptibility to frost action; high shrink-swell potential.
Kennebec: Ka	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding. Moderate if protected from flooding; moderate permeability; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; high susceptibility to frost action.
Lakeport: La	Severe: moderately slow permeability; seasonal high water table.	Moderate: seasonal water table at a depth of 2 to 4 feet.	Severe: seasonal high water table; silty clay subsoil.	Severe: seasonal high water table; high shrink-swell potential.	Severe: seasonal high water table; silty clay subsoil.	Severe: high shrink-swell potential; high susceptibility to frost action.
Lamo: Lb	Severe: moderately slow permeability; seasonal high water table; subject to flooding.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: seasonal high water table; subject to flooding; high shrink-swell potential.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; high susceptibility to frost action; seasonal high water table.
Luton: Ld	Severe: very slow permeability; seasonal high water table; subject to flooding.	Severe: subject to flooding. Slight if protected from flooding.	Severe: poorly drained; silty clay texture.	Severe: high shrink-swell potential; subject to flooding; seasonal high water table.	Severe: poorly drained; subject to flooding; silty clay texture.	Severe: poorly drained; subject to flooding; high shrink-swell potential.
McPaul: Ma	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding. Moderate if protected from flooding; moderate permeability.	Severe: subject to flooding. Moderate if protected from flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: seasonal high water table; subject to flooding.	Severe: subject to flooding; high susceptibility to frost action.
Modale: Mb	Severe: very show permeability in substratum; seasonal high water table; subject to flooding.	Severe: subject to flooding; seasonal high water table.	Severe: seasonal high water table; subject to flooding; silty clay substratum.	Severe: seasonal high water table; subject to flooding; high shrink-swell potential.	Severe: subject to flooding; seasonal high water table.	Severe: high shrink-swell potential; high susceptibility to frost action; subject to flooding.

See footnote at end of table.

interpretations of the soil—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions
Fair: moderate susceptibility to frost action; medium to low shear strength.	Unsuited	Good to fair: fair if surface is silty clay loam.	Moderate permeability; nearly level; seasonal high water table in places.	Medium to low shear strength; medium susceptibility to piping; fair compaction characteristics.	Well drained	High available water capacity; moderate intake rate.	Not needed.
Poor: low shear strength; high shrink-swell potential.	Unsuited	Poor: silty clay texture; high salt content; poorly drained.	Slow permeability; high water table.	Low shear strength; high shrink-swell potential; high compressibility.	Slow permeability.	Slow intake rate; high salt content; subject to flooding.	Not needed.
Poor: low shear strength; high susceptibility to frost action.	Unsuited	Fair: silty clay loam texture.	Moderate permeability; seasonal high high water table.	Low shear strength; high compressibility; fair to poor compaction characteristics.	Moderate permeability.	Subject to flooding; high available water capacity; moderately slow intake rate.	Not needed.
Poor: high shrink-swell potential.	Unsuited	Fair: silty clay loam texture.	Moderately slow permeability; seasonal high water table.	Medium to low shear strength; fair compaction characteristics; medium to high compressibility.	Moderately slow permeability; nearly level.	High available water capacity; slow intake rate; nearly level.	Not needed.
Poor: high susceptibility to frost action; high shrink-swell potential.	Unsuited	Fair: silty clay loam texture.	Moderately slow permeability; sandy layers below a depth of 40 inches in places; seasonal high water table.	Fair stability and compaction characteristics; high compressibility; medium to low shear strength.	Moderately slow permeability; seasonal high water table; level.	Subject to flooding; slow intake rate; seasonal high water table; high available water capacity.	Not needed.
Poor: high shrink-swell potential; poorly drained; low shear strength.	Unsuited	Poor: silty clay texture; poorly drained.	Very slow permeability; seasonal high water table; level.	Low shear strength; high compressibility; high shrink-swell potential.	Very slow permeability; subject to flooding.	Poorly drained; very slow intake rate.	Not needed.
Poor: high susceptibility to frost action.	Unsuited	Good	Moderate permeability; seasonal high water table; nearly level.	Medium to low shear strength; medium compressibility; medium susceptibility to piping.	Moderate permeability.	High available water capacity; moderate intake rate.	Not needed.
Poor: high shrink-swell potential; low shear strength; high susceptibility to frost action.	Unsuited	Good	Very slow permeability in substratum; seasonal high water table; nearly level.	Low shear strength; high susceptibility to piping; erodes easily.	Very slow permeability in substratum; subject to flooding.	Seasonal high water table; subject to flooding; moderate intake rate; very slow permeability in substratum.	Not needed.

TABLE 6.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Roads and streets
*Moody: McA, McB, MdC. For Nora part of MdC, see Nora series.	Moderate: moderate permeability.	Moderate if slopes are less than 7 percent; moderate permeability. Severe if slopes are more than 7 percent.	Slight if slopes are less than 8 percent, moderate if more than 8.	Moderate: moderate shrink-swell potential.	Moderate: silty clay loam texture.	Severe: high susceptibility to frost action.
*Nora: NeF------ For Crofton part, see Crofton series.	Moderate if slopes are less than 15 percent; moderate permeability. Severe if slopes are more than 15 percent.	Moderate if slopes are less than 7 percent; moderate permeability. Severe if slopes are more than 7 percent.	Slight if slopes are less than 8 percent, moderate if 8 to 15, severe if more than 15.	Moderate if slopes are less than 15 percent; moderate shrink-swell potential. Severe if slopes are more than 15 percent.	Slight if slopes are less than 15 percent, moderate if 15 to 25, severe if more than 25.	Severe: high susceptibility to frost action.
Omadi: Oa-------	Moderate: moderate permeability.	Moderate: moderate permeability.	Moderate: subject to flooding. Slight if protected from flooding.	Severe: subject to flooding. Moderate if protected from flooding; moderate shrink-swell potential.	Severe: subject to flooding. Slight to moderate if protected from flooding.	Moderate: moderate shrink-swell potential; moderate susceptibility to frost action.
Onawa: Ob------	Severe: subject to flooding; seasonal high water table; slow permeability in upper 2 feet.	Severe: subject to flooding; seasonal high water table.	Severe: silty clay in upper 25 inches; seasonal high water table; subject to flooding.	Severe: high shrink-swell potential; subject to flooding; seasonal high water table.	Severe: seasonal high water table; subject to flooding; silty clay texture.	Severe: high shrink-swell potential; subject to flooding.
Percival: Pa------	Severe: subject to flooding in places; seasonal high water table; slow permeability in upper 25 inches. [1]	Severe: seasonal high water table; subject to flooding; rapid permeability in substratum. [1]	Severe: seasonal high water table; subject to flooding; silty clay in upper part.	Severe: seasonal high water table; subject to flooding.	Severe: seasonal high water table; subject to flooding; rapid permeability in substratum. [1]	Severe: subject to flooding; high shrink-swell potential.
Salix: Sa---------	Severe: subject to flooding. Moderate if protected from flooding; moderate permeability; seasonal high water table.	Severe: subject to flooding. Moderate if protected from flooding; moderate permeability; seasonal high water table.	Severe: subject to flooding. Moderate if protected from flooding; seasonal high water table.	Severe: subject to flooding. Moderate if protected from flooding; seasonal high water table; moderate or high shrink-swell potential.	Severe: seasonal high water table; subject to flooding in places.	Severe: high susceptibility to frost action; moderate to high shrink-swell potential; subject to flooding in places.
Salmo: Sb-------	Severe: moderately slow permeability; subject to flooding; high water table.	Severe: subject to flooding; high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; high susceptibility to frost action; low shear strength.
Sarpy: ScB, SdA, SeA.	Slight if protected from flooding, severe if not protected from flooding. [1]	Severe: rapid permeability. [1]	Severe: subject to flooding; cutbanks cave.	Severe: subject to flooding. Slight if protected from flooding.	Severe: subject to flooding; rapid permeability.[1]	Severe: subject to flooding. Slight if protected from flooding.

See footnote at end of table.

interpretations of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions
Poor: high susceptibility to frost action; low shear strength.	Unsuited	Fair: silty clay loam texture.	Moderate permeability; nearly level to sloping.	Fair stability and compaction characteristics; medium to low shear strength.	Well drained	Moderately slow intake rate; high available water capacity; nearly level to sloping.	Nearly level to sloping; long, uniform slopes.
Poor: high susceptibility to frost action; low shear strength.	Unsuited	Fair: silty clay loam surface layer.	Moderate permeability; slopes of 2 to 50 percent.	Poor stability and compaction characteristics; low shear strength.	Well drained	Gently sloping to steep; moderately slow intake rate; high available water capacity.	Gently sloping to steep; long, uniform slopes; erodes easily.
Fair: medium to low shear strength; moderate shrink-swell potential.	Unsuited	Good	Moderate permeability; nearly level.	Medium to low shear strength; high susceptibility to piping; fair to poor compaction characteristics.	Well drained	High available water capacity; moderate intake rate.	Not needed.
Poor: low shear strength; high shrink-swell potential.	Unsuited	Poor: silty clay texture.	Moderate permeability in substratum; seasonal high water table; level.	High compressibility; low shear strength; fair compaction characteristics.	Moderate permeability in substratum; subject to flooding.	Very slow intake rate; moderate permeability in substratum; seasonal high water table.	Not needed.
Poor in upper part; high shrink-swell potential. Fair in lower part; somewhat poorly drained to poorly drained.	Unsuited	Poor: silty clay texture.	Rapid permeability in substratum; seasonal high water table; level.	High compressibility in upper part; low shear strength; high shrink-swell potential; sandy material below a depth of 25 inches.	Rapid permeability in substratum; subject to flooding.	Very slow intake rate; rapid permeability in substratum; level; seasonal high water table.	Not needed.
Poor: moderate to high shrink-swell potential; low to medium shear strength.	Unsuited	Fair: silty clay loam texture.	Moderate permeability; seasonal high water table; nearly level.	Low to medium shear strength; medium compressibility; fair compaction characteristics.	Moderate permeability.	High available water capacity; moderate intake rate; nearly level.	Not needed.
Poor: low shear strength; high susceptibility to frost action.	Unsuited	Poor: high salt content; silty clay loam texture.	Moderately slow permeability; seasonal high water table; level.	Low shear strength; moderate shrink-swell potential; fair to good compaction characteristics.	Subject to flooding; moderately slow permeability.	Subject to flooding; high water table; high salt content.	Not needed.
Good	Poor: excess fines; no gravel.	Poor: loamy fine sand texture.	Rapid permeability.	Medium to high susceptibility to piping; medium compacted permeability; unstable fill.	Excessively drained.	Rapid intake rate; very low to low available water capacity; very severe hazard of soil blowing.	Not needed.

TABLE 6.—*Engineering*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill	Roads and streets
Shindler: ShD, ShE.	Severe: moderately slow permeability in substratum; slopes of more than 15 percent in places.	Moderate if slopes are less than 7 percent, severe if more than 7.	Moderate if slopes are less than 15 percent; clay loam texture. Severe if slopes are more than 15 percent.	Moderate if slopes are less than 15 percent; moderate shrink-swell potential. Severe if slopes are more than 15 percent.	Moderate if slopes are less than 25 percent; clay loam texture. Severe if slopes are more than 25 percent.	Severe: low shear strength.
Storla: St	Severe: seasonal high water table. [1]	Severe: rapid permeability in substratum; seasonal high water table. [1]	Severe: cutbanks cave; seasonal high water table.	Severe: somewhat poorly drained.	Severe: rapid permeability in substratum; seasonal high water table. [1]	Severe: high susceptibility to frost action.
Thurman: TaB	Slight [1]	Severe: rapid permeability. [1]	Severe: cutbanks cave.	Slight	Severe: rapid permeability. [1]	Slight
*Wakonda: Wa. For Chancellor part, see Chancellor series; for Worthing part, see Worthing series.	Moderate or severe: seasonal high water table.	Moderate or severe: seasonal high water table.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained; seasonal high water table.	Severe: seasonal high water table.	Severe: high susceptibility to frost action.
*Wentworth: WbA, WbB, Wc. For Worthing part of Wc, see Worthing series.	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Moderate: moderate shrink-swell potential.	Moderate: silty clay loam texture.	Severe: high susceptibility to frost action.
Whitewood: Wh	Severe: moderately slow permeability; subject to flooding; seasonal high water table.	Severe: subject to flooding. Slight if protected from flooding and if water table is below floor of lagoon basin.	Severe: seasonal high water table; subject to flooding.	Severe: subject to flooding; seasonal high water table.	Severe: subject to flooding; seasonal high water table.	Severe: high susceptibility to frost action; low shear strength.
*Worthing: Wo, Ws. For Chancellor part of Ws, see Chancellor series.	Severe: slow permeability; subject to flooding; seasonal high water table.	Severe: subject to flooding. Slight if protected from flooding and water is below basin floor.	Severe: silty clay subsoil; seasonal high water table; subject to flooding.	Severe: high shrink-swell potential; seasonal high water table; subject to flooding.	Severe: seasonal high water table; subject to flooding; silty clay subsoil.	Severe: seasonal high water table; subject to flooding.

[1] Possible source of pollution of domestic water supplies.

interpretations of the soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand and gravel	Topsoil	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions
Poor: low shear strength.	Unsuited	Fair to poor; clay loam textures; poor if slopes are more than 15 percent.	Gently sloping to steep; moderately slow permeability in substratum.	Medium to high compressibility; fair to good stability and compaction characteristics.	Well drained	Gently sloping to steep; moderately slow intake rate; high available water capacity.	Short irregular slopes; gently sloping to steep; moderately slow permeability in substratum.
Fair: good material but site is somewhat poorly drained.	Fair: excess fines.	Fair: high lime content.	Rapid permeability in substratum.	Fair to poor stability and compaction characteristics; medium to high compressibility; gravelly sand substratum.	Rapid permeability in substratum.	Low to moderate available water capacity; moderate intake rate; high lime content.	Not needed.
Good	Fair: excess fines; no gravel.	Good to a depth of 10 inches, poor below.	Rapid permeability.	High susceptibility to piping; poor to fair stability.	Somewhat excessively drained.	Rapid intake rate; low to moderate available water capacity; severe hazard of soil blowing.	Not needed.
Poor: high susceptibility to frost action; low shear strength.	Unsuited	Fair: high lime content below a depth of 10 inches.	Moderate permeability; seasonal high water table; nearly level.	Fair to good stability and compaction characteristics; medium susceptibility to piping.	Moderate permeability; poor outlets.	Moderate intake rate; high lime content; moderate salinity; seasonal high water table.	Not needed.
Poor: high susceptibility to frost action; medium to low shear strength.	Unsuited	Fair: silty clay loam texture.	Moderate permeability; nearly level to gently sloping.	Fair to poor stability and compaction characteristics; medium to low shear strength; moderate shrink-swell potential.	Well drained	Moderately slow intake rate; high available water capacity; nearly level to gently sloping.	Nearly level to gently sloping; moderate permeability.
Poor: low shear strength; high susceptibility to frost action.	Unsuited	Fair: silty clay loam texture.	Moderately slow permeability; seasonal high water table.	Low shear strength; medium compressibility; fair to poor compaction characteristics.	Moderately slow permeability; poor availability of outlets.	Slow intake rate; seasonal high water table; subject to flooding.	Not needed.
Poor: medium to low shear strength; high shrink-swell potential.	Unsuited	Poor: poorly drained.	Slow permeability; seasonal high water table.	Fair to poor stability and compaction characteristics; high compressibility; high shrink-swell potential.	Slow permeability; poor availability of outlets.	Poorly drained; very slow intake rate.	Not needed.

TABLE 7.—*Engineering*

[Tests were made by the South Dakota Department of Highways according to standard

Soil name and location	Parent material	Depth	Horizon	Moisture density[1]	
				Maximum dry density	Optimum moisture
		Inches		*Lbs/cu ft*	*Percent*
Benclare silty clay loam: 1,230 feet west and 2,450 feet south of NE corner of sec. 25, T. 93 N., R. 49 W.	Silty and clayey alluvium	7–16	A12	90	27
		26–36	B22	96	24
		48–60	C2	101	21
Blyburg silt loam: 1,500 feet north and 129 feet west of SE corner of sec. 23, T. 90 N., R. 49 W.	Silty alluvial sediments	19–60	C2	100	22
Calco silty clay loam: 115 feet north and 2,380 feet east of SW corner of sec. 12, T. 94 N., R. 50 W.	Alluvium	8–18	A12	80	33
		39–47	C1g	91	26
Forney silty clay: 2,452 feet west and 3 feet south of NE corner of sec. 15, T. 89 N., R. 48 W.	Clayey alluvium	9–21	B2g	90	27
		21–27	IIA1b	86	30
		47–60	IIB3gb	85	30
Grable silt loam: 205 feet west and 106 feet south of NE corner of sec. 6, T. 90 N., R. 49 W.	Silty and sandy alluvium	7–15	C1	99	22
		15–27	C2	104	20
		27–60	IIC3	98	22
Lakeport silty clay loam: 135 feet west and 246 feet south of NE corner of sec. 19, T. 91 N., R. 50 W.	Silty alluvium	7–15	A12	95	24
		25–36	B22	89	28
		42–60	C	92	26
McPaul silt loam: 520 feet south and 1,130 feet west of NE corner of sec. 34, T. 94 N., R. 49 W.	Silty alluvium	6–41	C	101	21
		41–60	IIAb	83	32
Modale silt loam: 87 feet west and 825 feet south of NE corner of sec. 29, T. 90 N., R. 49 W.	Silty and clayey alluvium	11–24	C2	100	22
		24–60	IIC3g	89	28
Omadi silt loam: 123 feet west and 2,460 feet north of SE corner of sec. 7, T. 90 N., R. 49 W.	Silty alluvium	11–19	AC	95	24
		28–48	C3	95	24
Percival silty clay: 2,273 feet north and 90 feet west of SE corner of sec. 25, T. 91 N., R. 50 W.	Clayey alluvium over sandy alluvium.	7–25	C1g	89	28
		25–60	IIC2	99	22
Salix silty clay loam: 2,480 feet west and 1,220 feet north of SE corner of sec. 29, T. 90 N., R. 48 W.	Silty alluvium	6–14	A12	95	24
		14–22	B2	90	27
		33–60	C1	102	20
Sarpy loamy fine sand: 290 feet east and 760 feet north of SW corner of sec. 31, T. 90 N., R. 48 W.	Sandy alluvium	8–60	C2	99	22
Shindler clay loam: 2,550 feet west and 210 feet north of SE corner of sec. 19, T. 95 N., R. 48 W.	Glacial till	8–13	B2	101	21
		18–33	C1ca	106	19

[1] Based on the Moisture-density Relations of Soils Using 5.5-lb. Rammer and 12-in. Drop, AASHTO Designation: T 99, Method 3.
[2] Mechanical analysis according to the AASHTO Designation: T 88. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

test data

procedures of the American Association of State Highway and Transportation Officials (AASHTO)]

Mechanical analysis [2]					Liquid limit	Plasticity index	Classification	
Percentage passing sieve—				Percentage smaller than 0.005 mm			AASHTO [3]	Unified [4]
No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)					
----------	----------	100	94	49	52	21	A-7-5(14)	MH
----------	----------	100	92	43	49	19	A-7-5(14)	ML
----------	----------	100	90	35	44	20	A-7-6(13)	CL
----------	----------	100	86	11	26	[5] NP	A-4(8)	ML
----------	100	99	93	41	59	17	A-7-5(15)	MH
----------	100	99	97	49	60	29	A-7-5(20)	MH
----------	----------	100	99	49	63	30	A-7-5(20)	MH
----------	----------	100	99	67	76	39	A-7-5(20)	MH
----------	----------	100	99	77	85	45	A-7-5(20)	MH
----------	----------	100	93	23	34	10	A-4(8)	ML
----------	----------	100	46	7	23	NP	A-4(2)	SM
----------	----------	100	8	3	24	NP	A-3(0)	SP-SM
----------	----------	100	98	45	47	19	A-7-6(13)	ML
----------	----------	100	99	67	72	37	A-7-5(20)	MH
----------	----------	----------	100	63	65	34	A-7-5(20)	CH
----------	100	99	98	27	39	14	A-6(10)	ML
----------	----------	100	98	39	55	15	A-7-5(13)	MH
----------	----------	100	69	7	26	NP	A-4(6)	ML
----------	----------	----------	100	75	76	39	A-7-5(20)	MH
----------	----------	100	99	35	44	16	A-7-6(11)	ML
----------	----------	100	99	39	47	19	A-7-6(14)	CL
----------	----------	100	98	69	71	33	A-7-5(20)	MH
----------	----------	100	99	1	24	NP	A-3(0)	SP-SM
----------	----------	100	96	41	45	16	A-7-6(12)	ML
----------	----------	100	98	41	49	13	A-7-5(11)	ML
----------	----------	100	98	21	34	8	A-4(8)	ML
----------	----------	100	4	1	23	NP	A-3(0)	SP
98	97	89	70	36	40	12	A-7-5(8)	ML
99	98	91	76	42	46	22	A-7-6(13)	CL

[3] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1, Ed. 8): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHTO Designation: M 145–49.
[4] Based on the Unified Soil Classification System, Technical Memorandum No. 3–357, Volume 1, Waterways Experiment Station, Corps of Engineers, March 1953.
[5] NP means nonplastic.

TABLE 8.—*Engineering test data for soil samples*

[Tests made by the South Dakota Department of Highways.

Soil series	Horizon	Number of samples tested	Mechanical analysis [1]					
			Percentage less than 3 inches passing sieve—					
			No. 10 (2.0 mm)		No. 40 (0.42 mm)		No. 200 (0.074 mm)	
			Range	Average	Range	Average	Range	Average
Albaton	A	4	----------	100	----------	100	97–99	98
	C	23	----------	100	98–100	99	81–100	95
Alcester	A	21	98–100	100	88–100	97	73–100	89
	B	30	98–100	100	93–100	98	84–100	94
	C	23	99–100	100	95–100	98	81–100	93
Benclare	A	5	----------	100	97–100	99	87–97	92
	B	9	----------	100	97–100	99	85–100	93
	C	4	98–100	100	87–100	95	66–100	85
	IIC	1	----------	98	----------	81	----------	46
Chancellor	A	8	99–100	100	95–99	97	86–95	90
	B	4	----------	100	97–100	99	86–100	95
	C	4	99–100	100	94–100	98	78–100	92
	IIC	3	96–100	98	94–96	95	79–89	84
Crofton	C	41	99–100	100	96–100	99	89–100	97
Davis	A	12	89–100	96	79–100	90	54–84	70
	B	7	92–100	97	81–100	91	47–96	71
	C	23	94–100	97	84–98	91	57–89	73
Dempster	B	6	96–100	99	79–100	92	36–100	70
	IIC	12	58–100	86	31–100	69	0–54	27
Egan	A	46	99–100	100	94–100	97	82–99	90
	B	156	97–100	99	92–100	97	79–100	90
	C	36	80–100	97	71–100	92	52–100	83
	IIC	83	82–100	95	68–100	87	39–56	67
Enet	A	7	91–100	96	72–94	83	46–79	62
	B	21	93–100	97	67–100	83	38–84	61
	C	15	54–100	79	10–83	47	0–49	21
	IIC	55	41–100	70	8–79	44	3–41	22
Forney	B	10	----------	100	----------	100	97–100	99
Graceville	A	4	95–100	99	89–98	94	66–92	79
	B	16	95–100	99	83–100	92	50–99	75
	IIC	17	50–100	80	23–94	58	1–55	28
Haynie	A	1	----------	100	----------	100	----------	98
	C	24	----------	100	----------	100	77–100	90
Lamo	A	22	95–100	99	89–100	96	64–100	82
	B	48	92–100	98	84–100	94	62–100	83
	C	47	93–100	98	80–100	94	54–100	79
	IIC	4	54–100	83	14–100	60	0–48	22
Luton	A	10	98–100	100	85–100	94	58–100	80
	B	21	98–100	100	91–100	97	70–100	91
	C	29	98–100	99	82–100	93	57–100	80
	IIC	14	65–100	89	19–100	61	0–40	18
Modale	A	3	----------	100	----------	100	93–100	97
	C	5	98–100	100	97–100	99	80–100	91
	IIC	8	----------	100	99–100	100	90–100	97

See footnotes at end of table.

taken along proposed highway routes

Dashes indicate that soils were not tested for that property]

Mechanical analysis [1]—Continued: Percentage smaller than 0.005 mm		Liquid limit [2]		Plasticity index [3]		Classification			Estimated CBR [7]
Range	Average	Range	Average	Range	Average	AASHTO [4] (Old index)	AASHTO [5] (New index)	Unified [6]	
56–69	62	59–73	66	40–46	43	A-7-6(20)	A-7-6(48)	CH	2
47–68	57	50–70	60	28–45	36	A-7-6(20)	A-7-6(39)	CH	2
8–33	20	37–49	43	10–21	15	A-7-6(11)	A-7-6(16)	ML	4
10–40	24	36–49	42	11–23	16	A-7-6(11)	A-7-6(18)	ML	5
11–46	28	32–51	42	10–27	18	A-7-6(12)	A-7-6(19)	CL	5
14–47	30	41–56	48	13–28	20	A-7-6(14)	A-7-6(22)	ML	4
16–64	40	36–70	53	13–46	29	A-7-6(18)	A-7-6(30)	CH	3
28–40	34	38–69	54	20–42	31	A-7-6(19)	A-7-6(28)	CH	3
----------	20	----------	29	----------	16	A-6(4)	A-6(3)	SC	9
25–48	36	47–57	51	17–31	24	A-7-6(16)	A-7-6(25)	CH	3
22–58	40	47–61	54	26–33	29	A-7-6(19)	A-7-6(32)	CH	3
29–71	49	38–59	49	19–39	29	A-7-6(17)	A-7-6(29)	CL	3
32–50	41	40–46	43	20–27	23	A-7-6(14)	A-7-6(20)	CL	4
16–38	26	30–46	38	7–24	15	A-6(10)	A-6(16)	CL	6
10–40	25	38–53	45	15–23	19	A-7-6(11)	A-7-6(13)	CL–ML	4
13–37	25	32–45	39	13–22	17	A-6(10)	A-6(11)	CL	5
23–57	39	31–53	42	13–32	22	A-7-6(13)	A-7-6(15)	CL	5
7–47	27	22–55	39	4–32	17	A-6(10)	A-6(11)	CL	5
0–30	11	8–36	22	0–19	6	A-2-4(0)	A-2-4(0)	SM–SC	[8]
21–47	34	41–51	46	14–25	19	A-7-6(13)	A-7-6(20)	ML	4
19–54	36	38–52	45	15–30	22	A-7-6(14)	A-7-6(22)	CL	4
13–58	35	30–56	43	10–35	22	A-7-6(14)	A-7-6(19)	CL	4
12–52	32	24–51	38	8–30	19	A-6(10)	A-6(11)	CL	6
0–38	19	28–54	41	5–22	13	A-7-6(7)	A-7-6(7)	ML	5
10–38	24	28–50	39	7–27	16	A-6(8)	A-6(8)	CL	5
0–25	10	17–37	27	0–19	9	A-2-4(0)	A-2-4(0)	SC	[8]
0–21	9	16–43	30	0–23	11	A-2-6(0)	A-2-6(0)	SC	[8]
35–80	57	54–83	68	29–61	44	A-7-6(20)	A-7-6(51)	CH	1
4–33	18	38–47	43	11–22	16	A-7-6(11)	A-7-6(14)	ML	4
8–37	22	25–47	36	7–24	15	A-6(10)	A-6(10)	CL	6
0–26	10	2–39	21	0–20	7	A-2-4(0)	A-2-4(0)	SM–SC	[8]
----------	30	----------	42	----------	20	A-7-6(12)	A-7-6(22)	CL	5
12–45	28	26–46	36	3–24	13	A-6(10)	A-6(13)	CL	6
15–44	29	34–55	45	8–31	19	A-7-6(13)	A-7-6(17)	CL	4
14–44	29	31–55	43	10–33	21	A-7-6(13)	A-7-6(18)	CL	4
14–51	32	31–59	43	10–36	22	A-7-6(13)	A-7-6(18)	CL	4
0–20	9	0–38	13	0–18	5	A-2-4(0)	A-2-4(0)	SM–SC	[8]
5–59	31	33–71	52	12–44	28	A-7-6(18)	A-7-6(23)	CH	3
14–72	42	38–71	55	15–49	32	A-7-6(19)	A-7-6(32)	CH	3
3–52	27	19–65	42	4–41	22	A-7-6(14)	A-7-6(18)	CL	5
0–15	5	0–30	11	0–11	3	A-2-4(0)	A-2-4(0)	SM	[8]
24–52	38	27–52	39	5–29	16	A-6(11)	A-6(17)	CL	5
0–76	36	18–52	35	0–27	13	A-6(9)	A-6(12)	CL	6
41–70	55	51–70	61	29–43	35	A-7-6(20)	A-7-6(40)	CH	2

TABLE 8.—*Engineering test data for soil samples*

Soil series	Horizon	Number of samples tested	Mechanical analysis [1] — Percentage less than 3 inches passing sieve— No. 10 (2.0 mm) Range	No. 10 (2.0 mm) Average	No. 40 (0.42 mm) Range	No. 40 (0.42 mm) Average	No. 200 (0.074 mm) Range	No. 200 (0.074 mm) Average
Moody	A	67	98–100	100	97–100	99	90–100	96
	B	163	98–100	100	95–100	99	86–100	96
	C	105	99–100	100	95–100	99	84–100	95
	IIC	7	89–100	95	82–96	89	56–83	70
Nora	A	14	-----	100	99–100	99	95–99	97
	B	41	96–100	99	91–100	97	77–100	92
	C	11	98–100	99	89–100	96	67–100	86
	IIC	1	-----	100	-----	97	-----	69
Onawa	A	2	-----	100	-----	100	97–100	99
	C	9	99–100	100	96–100	99	91–100	97
	IIC	11	98–100	99	97–100	99	84–100	94
Storla	A	2	97–100	99	74–92	83	46–81	64
	B	3	88–100	94	61–96	78	24–79	51
	C	1	-----	97	-----	89	-----	64
	IIC	2	69–83	76	35–45	40	3–27	15
Thurman	A	6	97–100	99	82–95	89	15–40	28
	C	14	84–100	95	58–100	83	1–52	27
Wakonda	A	1	-----	100	-----	100	-----	94
	C	1	-----	100	-----	100	-----	94
Wentworth	A	51	94–100	99	88–100	96	69–100	86
	B	171	94–100	99	87–100	95	65–100	86
	C	103	94–100	98	85–100	94	59–100	81
	IIC	28	68–100	90	48–100	78	27–87	57
Whitewood	A	8	98–100	100	93–100	97	70–100	86
	B	16	99–100	100	94–100	97	72–100	88
	C	8	83–100	95	65–100	87	23–100	68
	IIC	1	-----	96	-----	90	-----	78
Worthing	A	4	97–100	99	91–100	97	68–100	87
	B	14	98–100	100	94–100	97	77–100	89
	C	11	95–100	98	88–100	95	67–98	83

[1] Mechanical analyses according to the AASHTO designation T88. Results by this procedure may differ somewhat from the results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHTO procedure, the fine material is analyzed by the hydrometer method, and the various grain-size fractions are calculated on the basis of all material up to and including that 3 inches in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method, and the material coarser than 2 millimeters in diameter is excluded from the calculations of grain-size fractions. The mechanical analyses data used in this table are not intended for naming textural classes of soil.

[2] Based on AASHTO Designation T 89–60.

[3] Based on AASHTO Designation T 90–61.

Engineering interpretations

The estimated interpretations in table 6 are based on the engineering properties of soils shown in table 5, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Union County. In table 5 ratings are used to summarize the limitations or suitability of the soils for all listed purposes other than for drainage of cropland and pasture, irrigation, ponds and reservoirs, embankments, and terraces and diversions. For these particular uses, table 6 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings *slight*, *moderate*, and *severe*. *Slight* means that soil properties generally are favorable for the rated use, or in other words, the limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means that soil properties are so unfavorable and so difficult to correct or overcome that they require major soil reclamation and special designs.

taken along proposed highway routes—Continued

Mechanical analysis [1]—Continued: Percentage smaller than 0.005 mm		Liquid limit [2]		Plasticity index [3]		Classification			Estimated CBR [7]
Range	Average	Range	Average	Range	Average	AASHTO [4] (Old index)	AASHTO [5] (New index)	Unified [6]	
11–45	27	40–51	45	12–22	16	A-7-6(12)	A-7-6(19)	ML	4
16–45	30	32–49	41	10–26	18	A-7-6(11)	A-7-6(19)	CL	5
20–40	29	32–45	38	10–25	17	A-6(11)	A-6(17)	CL	6
14–39	26	20–49	34	5–28	16	A-6(9)	A-6(9)	CL	7
8–28	18	35–47	41	10–17	13	A-7-6(9)	A-7-6(15)	CL–ML	5
11–38	24	28–46	37	6–23	14	A-6(10)	A-6(14)	CL	6
16–39	27	30–46	38	9–28	18	A-6(11)	A-6(16)	CL	6
	21		27		8	A-4(7)	A-4(4)	CL	10
44–62	53	48–58	53	23–33	28	A-7-6(18)	A-7-6(32)	CH	3
34–78	56	47–67	57	24–44	33	A-7-6(19)	A-7-6(37)	CH	3
18–52	34	29–51	40	7–31	19	A-6(12)	A-6(19)	CL	5
13–41	27	43–50	47	23–26	24	A-7-6(13)	A-7-6(14)	CL	4
13–29	21	32–48	40	9–27	18	A-6(6)	A-6(6)	CL	5
	31		31		17	A-6(9)	A-6(8)	CL	8
0–15	6	19–30	25	0–18	7	A-2-4(0)	A-2-4(0)	SC	(8)
6–16	10	18–27	23	0–10	4	A-2-4(0)	A-2-4(0)	SM–SC	(8)
4–18	11	17–27	22	0–11	5	A-2-4(0)	A-2-4(0)	SM–SC	(8)
	35		40		22	A-6(13)	A-6(21)	CL	5
	43		42		25	A-7-6(14)	A-7-6(24)	CL	5
7–43	25	36–52	44	10–25	17	A-7-6(12)	A-7-6(17)	ML	4
11–45	28	34–50	42	12–27	19	A-7-6(12)	A-7-6(17)	CL	5
15–46	30	30–50	40	10–29	19	A-6(12)	A-6(16)	CL	5
2–43	22	20–46	33	6–27	16	A-6(7)	A-6(6)	CL	7
7–55	31	43–59	51	12–30	21	A-7-5(15)	A-7-5(21)	MH	3
15–50	32	39–60	50	14–32	23	A-7-6(15)	A-7-6(23)	CH	3
0–56	28	20–57	39	2–36	19	A-6(10)	A-6(11)	CL	5
	51		48		28	A-7-6(17)	A-7-6(22)	CL	4
28–44	36	42–55	49	19–26	22	A-7-6(15)	A-7-6(22)	CL	3
27–48	37	34–72	53	11–46	28	A-7-6(18)	A-7-6(28)	CH	3
24–59	41	31–63	47	14–40	26	A-7-6(16)	A-7-6(22)	CL	4

[4] Based on AASHTO Designation M 145–49.
[5] Based on AASHTO Designation M 145–66I.
[6] Based on the Unified Soil Classification System, Technical Memorandum No. 3–357, Volume 1, Waterways Experiment Station, Corps of Engineers, March 1953.
[7] Estimated values based on relationships between California Bearing Ratio and liquid limit.
[8] California Bearing Ratio (CBR) and liquid limit relationship is not applicable to granular classifications A–1, A–2, and A–3 and to subgroups of these classifications.

Soil suitability is rated by the terms *good*, *fair*, and *poor*, which have meanings approximately parallel to the terms *slight*, *moderate*, and *severe*.

Following are explanations of some of the columns in table 6.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor; its sides, or embankments, are of soil material compacted to medium density; and the pond is protected from flooding. Properties that affect the pond floor are permeability, or-

ganic-matter content, and slope. If the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification and the amount of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet. Examples are excavations for pipelines, sewer lines, phone and power transmission lines, basements, open ditches, and graves. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or absence of a high water table.

Dwellings, as rated in table 6, are not more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings are those that relate to capacity to support load and resist settlement under load and those that relate to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. The waste is spread in thin layers, compacted, and covered with soil. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 6 apply only to soil material to a depth of about 6 feet, so a limitation of *slight* or *moderate* may not be valid if trenches are to be much deeper. For some soils, reliable predictions can be made to a depth of 10 or 15 feet; nevertheless, every site should be investigated before it is selected.

Local roads and streets, as rated in table 6, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are the load-supporting capacity and stability of the subgrade and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material and the shrink-swell potential indicate traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage, and the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 6 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source generally has a layer of sand or gravel at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and neither do they indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as in preparing a seedbed; natural fertility of the material or plant response when fertilizer is added to the soil; absence of substances toxic to plants; and texture of the soil material and its content of stone fragments. Also considered in this rating is damage that will result at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage and piping and that is of favorable stability, shrink-swell potential, shear strength, and compactibility. Stones or organic material in a soil are among factors that are unfavorable.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulation of salts and alkali; depth of root zone; rate of water intake at the surface; permeability below the surface layer and in fragipans or other layers that restrict movement of water; amount of water available to plants; and need for drainage, or depth to water table or bedrock.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or to other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Engineering test data

Tables 7 and 8 contain engineering test data for some of the soil series in Union County. The tests were made by the South Dakota Department of Highways in accordance with standard procedures of the American Association of State Highway and Transportation Officials. Table 7 shows the results of tests on selected horizons of five soils at specific locations in Union County. Table 8 summarizes the tests made on soil samples collected along proposed highway routes in this and adjacent counties.

In table 8 the horizon column gives the major horizons from which samples were taken. The samples were taken at depths that indicated distinct contrasts in color and texture and, therefore, may include material from more than

one major horizon. The number of samples taken for each horizon also is shown. The actual range and average value for each of the several properties are given; but because of the method of sampling, the range in properties shown in table 8 may differ from the range shown in table 5.

Some of the columns in tables 7 and 8 are explained in the following paragraphs.

Compaction, or moisture-density, data are important in earthwork. If a soil material is compacted at successively higher moisture contents, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil material, as explained for table 5.

Mechanical analyses show the percentages, by weight, of soil particles that pass sieves of specified sizes. Sand and other coarse particles do not pass through the No. 200 sieve, but silt and clay do. The percentages of particles smaller than those passing the No. 200 sieve were determined by the hydrometer method rather than by the pipette method which most soil scientists use in determining the clay content of soil samples.

California bearing ratio (CBR) expresses the load-supporting capacity of a soil as compared to that of standard crushed limestone. The estimated values shown in table 7 are related to liquid limit. Generally, the soils that have a high liquid limit have a low CBR value.

Land Use Planning

Information about soils is important in planning and developing sites for nonfarm uses. Land appraisers, realtors, city planners, builders, and others need facts that help them to determine what soils are suitable for homes and other buildings and what areas are better suited to other uses. This information is obtained by using the soil maps in this survey to identify the soils and then referring to the sections "Descriptions of the Soils" and "Engineering Uses of the Soils." It should be emphasized, however, that it is desirable to make detailed samples and tests at the exact site of proposed installations.

A knowledge of soil properties is important in determining the suitability of a site for a subdivision or an individual home. Table 5 lists the estimated properties significant in engineering for each soil in the county. It also places the soils in the Unified classification system and, thus, groups them in respect to their performance as construction and foundation material. Generally, GW, GM, GC, SW, SM, and SC groups have slight limitations as construction material; ML and CL groups have moderate limitations; and CH and MH groups have severe limitations.

Table 6 provides engineering interpretations of soils that are useful for planning the installation of septic tank absorption fields, sewage lagoons, and shallow excavations for various purposes; and for locating sites for dwellings and other low buildings, sanitary landfills, and roads and streets.

Erosion of sloping soils is a serious hazard in construction areas. The exposed cuts, paving, and compaction of soil material that are common during construction increase runoff to several times the amount expected when the same soil is used for crops and pasture. The concentration of such runoff in streets and gutters results in flooding and deposition of sediment in low areas below the construction site.

Soil properties need to be considered in planning recreation uses, such as athletic areas, campsites, golf courses, picnic areas, playground areas, and paths and trails. Nearly level and gently sloping soils that have adequate drainage and favorable surface textures and other qualities favorable to foot traffic are well suited. Desirable sites are also free of stones and are not subject to flooding during the season of use. The section "Descriptions of the Soils" gives information on these characteristics of the soils.

Formation and Classification of the Soils

This section consists of two parts. The first part discusses the five factors of soil formation as they relate to the soils of Union County. The second describes the system for classifying soils and places the soil series of the county in this system.

Factors of Soil Formation

Soil is produced by soil-forming processes acting on material deposited or accumulated by geologic forces. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent material; the climate under which the soil material has accumulated and existed since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the development of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

Most of the soils in the county formed in alluvium and loess. Material deposited by glacial action is the other major parent material.

Soils formed in alluvium make up nearly half the acreage of the county. These stream-deposited materials consist of silt, clay, sand, and gravel and commonly are stratified. Much of the alluvium is on bottom lands that are now or have recently been subjected to sediment deposition. Generally the alluvial soils on the lower flood plains lack the dis-

tinct horizons resulting from soil forming processes. Examples of these young alluvial soils are in the Albaton, Calco, Haynie, McPaul, Onawa, and Sarpy series. Alcester, Blencoe, Davis, Forney, and Salix soils are examples of alluvial soils on some higher bottoms.

Loess mantles much of the northern part of the county. These wind-deposited materials have a high content of silt and very fine sand and range from 5 to 20 or more feet in thickness. Crofton, Moody, and Nora soils formed in loess.

Soils that formed in material deposited by glacial action are on uplands mostly along the western side of the county. Four major glacial stages, the Nebraskan, Kansan, Illinoian, and Wisconsin, covered the county during the Pleistocene period (*4*). Materials deposited during the Illinoian and Wisconsin stages are the only glacial deposits in which the soils of Union County formed.

Glacial till is a mixture of clay, silt, sand, and gravel that contains few to many cobbles and boulders. The proportion of each depends on the kinds of material passed over by the glacier. Shindler soils are the main soils formed in glacial till. Chancellor and Worthing soils are in depressions and low areas on glacial till plains and formed in local alluvium washed from adjacent soils.

Silty glacial drift consists of material deposited on glacial ice, reworked by water, and distorted by sliding. This kind of glacial deposit has a high content of silt and commonly is stratified with coarser materials. Wakonda and Wentworth soils formed in silty glacial drift. Egan soils formed in a thin mantle of silty glacial drift that is underlain by glacial till or loamy glacial drift at moderate depths.

Outwash sand and gravel are material sorted and washed by the melt water of glaciers. These deposits are on stream terraces and till plains along the larger drainageways. Dempster, Enet, and Graceville soils formed in loamy and silty material overlying outwash sand and gravel.

Climate

Union County has a subhumid climate characterized by cold winters, cool springs with considerable precipitation, hot summers, and mild autumns with occasional rainy periods. In winter soil-forming processes are mostly dormant. The soils are frozen to a depth of 2 or 3 feet for 4 or 5 months of the year. The depth to which the frost penetrates depends mostly on the amount of snowfall late in fall or early in winter. Most of the rainfall comes in the first half of the growing season, and a period of deficient rainfall commonly occurs late in summer. More climatic data are given in the section "Environmental Factors Affecting Soil Use."

Climate, as a factor of soil formation, affects the weathering of parent material through precipitation, fluctuation in temperature, and the working of wind. Large differences in climate can produce large differences in the soils that are formed. The climate is fairly uniform throughout Union County, however, and differences in the soils cannot be attributed to differences in climate alone. Its effects are modified by the effects of the other four factors of soil formation.

Plant and animal life

Many living organisms are important to soil formation. These include vegetation, animals, and micro-organisms such as bacteria and fungi. The vegetation is generally responsible for the amount of organic matter, the color of the surface layer, and the amount of nutrients. Plant roots penetrate the soil, make it porous, and encourage the development of soil structure. The roots take up minerals in solution from the lower parts of the soil and eventually return them to the surface in the form of organic matter. Animals, such as earthworms, cicadas, and burrowing animals, help to keep the soil open and porous and help to mix the humus with the soils. Earthworm activity is very evident in friable, silty and loamy soils, such as those of the Moody and Shindler series, but is less evident in clayey soils, such as those of the Albaton and Forney series. Burrowing animals have mixed the soil horizons in some places, but their activities are less important than those of earthworms. Micro-organisms such as bacteria and fungi decompose vegetation, thus releasing nutrients for plant food.

In Union County, mid and tall prairie grasses have had more influence on soil formation than any other living organism. The darkest colored, most fertile soils, such as Alcester and Kennebec soils, generally formed where conditions were most favorable for dense vegetation. The lighter colored, less fertile soils, such as Crofton and Shindler soils, formed in areas where conditions were not favorable for good stands of vegetation, such as on steeper slopes.

Man has had only a minor influence on soil development, but he has had a great influence on the potential of the soils to support plants and animals. He has removed the native vegetation from the soil and pulverized the surface layer through plowing and cultivation. He has used inadequate cropping sequences and failed to control runoff; consequently, many sloping soils have lost much of their original topsoil by accelerated erosion.

Relief

Relief, or lay of the land, influences the formation of soil mainly through its effect on runoff and drainage.

The soils in Union County are on nearly level bottom lands, upland plains, and steep river breaks. Soil development, therefore, varies greatly. Maximum development takes place in well drained, nearly level or gently sloping soils, such as Moody and Wentworth soils. Little or no development takes place in soils in depressions or on bottom lands that are flooded or have a high water table, such as Albaton soils. Profile development is also slow on slopes where runoff is rapid; soil horizons are thinner and less distinct than in less sloping soils. Lime is not so deeply leached in the steeper soils, such as Crofton and Shindler soils. Soils that receive beneficial moisture from runoff, such as Alcester soils, have thick, dark colored profiles, and lime is leached deeply.

More data on relief in Union County are given in the section "Environmental Factors Affecting Soil Use."

Time

The formation of soils requires many years for changes to take place in the parent material. A soil's age, however, is determined by the degree of soil development in a soil profile. Soils that have little or no development are immature, while those that have well expressed soil horizons are mature, even though the parent materials from which they formed are the same age.

Generally the longer the parent material has remained in place, the more fully developed the horizons in the soil profile are. Because of differences in parent material and relief, however, some soils develop more slowly than others.

The youngest soils, such as Calco and McPaul soils, formed in recent alluvium. They remain young because new parent

material is deposited periodically by floodwaters. The constantly moist condition of some alluvial soils also inhibits soil forming processes. Steeper soils are likely to be less developed than gently sloping soils. Steep soils, such as Crofton soils, remain young because soil material is removed by erosion almost as soon as it forms and, consequently, no well-defined horizons develop. These soils, therefore, have been affected little by time.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (*8*).

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. The same property or subdivisions of this property may be used in several different categories. In table 9 the soil series of Union County are placed in four categories of the current system. Classes of the

TABLE 9.—*Classification of soil series*

Series	Family	Subgroup	Order
Albaton	Fine, montmorillonitic (calcareous), mesic	Vertic Fluvaquents	Entisols.
Alcester	Fine-silty, mixed, mesic	Cumulic Haplustolls	Mollisols.
Benclare	Fine, montmorillonitic, mesic	Pachic Haplustolls	Mollisols.
Blencoe	Clayey over loamy, montmorillonitic, mesic	Aquic Hapludolls	Mollisols.
Blyburg	Coarse-silty, mixed, mesic	Fluventic Hapludolls	Mollisols.
Calco	Fine-silty, mixed (calcareous), mesic	Cumulic Haplaquolls	Mollisols.
Chancellor	Fine, montmorillonitic, mesic	Typic Argiaquolls	Mollisols.
Crofton	Fine-silty, mixed (calcareous), mesic	Typic Ustorthents	Entisols.
Davis	Fine-loamy, mixed, mesic	Pachic Haplustolls	Mollisols.
Dempster	Fine-silty over sandy or sandy-skeletal, mixed, mesic	Udic Haplustolls	Mollisols.
Egan	Fine-silty, mixed, mesic	Udic Haplustolls	Mollisols.
Enet [1]	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Pachic Haplustolls	Mollisols.
Fluvaquents	Loamy, mixed (calcareous), mesic	Typic Fluvaquents	Entisols.
Forney	Fine, montmorillonitic, nonacid, mesic	Vertic Fluvaquents	Entisols.
Grable	Coarse-silty over sandy or sandy-skeletal, mixed (calcareous), mesic.	Mollic Udifluvents	Entisols.
Graceville	Fine-silty, mixed, mesic	Pachic Haplustolls	Mollisols.
Haynie [2]	Coarse-silty, mixed (calcareous), mesic	Mollic Udifluvents	Entisols.
James	Fine, montmorillonitic (calcareous), mesic	Cumulic Haplaquolls	Mollisols.
Kennebec	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Lakeport [3]	Fine, montmorillonitic, mesic	Aquic Hapludolls	Mollisols.
Lamo	Fine-silty, mixed (calcareous), mesic	Cumulic Haplaquolls	Mollisols.
Luton	Fine, montmorillonitic, mesic	Vertic Haplaquolls	Mollisols.
McPaul	Coarse-silty, mixed (calcareous), mesic	Mollic Udifluvents	Entisols.
Modale	Coarse-silty over clayey, mixed (calcareous), mesic	Aquic Udifluvents	Entisols.
Moody	Fine-silty, mixed, mesic	Udic Haplustolls	Mollisols.
Nora	Fine-silty, mixed, mesic	Udic Haplustolls	Mollisols.
Omadi	Fine-silty, mixed, mesic	Fluventic Hapludolls	Mollisols.
Onawa	Clayey over loamy, montmorillonitic (calcareous), mesic	Mollic Fluvaquents	Entisols.
Percival	Clayey over sandy or sandy-skeletal, montmorillonitic (calcareous), mesic.	Aquic Udifluvents	Entisols.
Salix	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Salmo	Fine-silty, mixed (calcareous), mesic	Cumulic Haplaquolls	Mollisols.
Sarpy	Mixed, mesic	Typic Udipsamments	Entisols.
Shindler	Fine-loamy, mixed, mesic	Udorthentic Haplustolls	Mollisols.
Storla	Fine-loamy over sandy or sandy-skeletal, mesic	Aeric Calciaquolls	Mollisols.
Thurman	Sandy, mixed, mesic	Udorthentic Haplustolls	Mollisols.
Wakonda	Fine-silty, mesic	Aeric Calciaquolls	Mollisols.
Wentworth	Fine-silty, mixed, mesic	Udic Haplustolls	Mollisols.
Whitewood	Fine-silty, mixed, mesic	Cumulic Haplaquolls	Mollisols.
Worthing	Fine, montmorillonitic, mesic	Typic Argiaquolls	Mollisols.

[1] Enet soils are taxadjuncts because they have thicker transitional horizons of sandy loam and they are more deeply leached than is described as the range of the series.

[2] Haynie soils are taxadjuncts because the surface layer is lighter than very dark grayish brown (10YR 3/2 or 2.5Y 3/2), moist.

[3] Lakeport soils are taxadjuncts because of fine stratification in the control section.

current system are briefly defined in the following paragraphs.

ORDER.—Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. Three exceptions to this are the Entisols, Histosols, and Vertisols, which occur in many different climates. Each order is named with a word of three or four syllables ending in *sol.* An example is *Mollisol.*

SUBORDER.—Each order is divided into suborders using those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders are more narrowly defined than the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of a water table at a shallow depth; soil climate; the accumulation of clay, iron, or organic carbon in the upper solum; cracking of soils caused by a decrease in soil moisture; and fine stratification. The names of suborders have two syllables. The last syllable indicates the order. An example is *Aquoll* (*Aqu*, meaning water or wet, and *oll*, from Mollisol).

GREAT GROUP.—A soil suborder is divided into great groups on the basis of uniformity in the kinds and sequence of soil horizons and features. The horizons used to make separations are those in which clay, carbonates, and other constituents have accumulated or have been removed; and those that have pans that interfere with growth of roots, movement of water, or both. Some features used are soil acidity, soil climate, soil composition, and soil color. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is Haplaquoll (*Hapl*, meaning simple horizons, and *aquoll*, as defined under suborder).

SUBGROUP.—A great group is divided into subgroups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Other subgroups may have soil properties unlike those of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Haplaquolls (a typical Haplaquoll).

FAMILY.—Soil families are separated within a subgroup primarily on the basis of properties important to the growth of plants or to the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, soil depth, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and other criteria that are used as family differentiae.

Environmental Factors Affecting Soil Use

The major natural and cultural factors affecting the use and management of the soils in Union County are discussed in this section. These factors include natural vegetation, relief, water, climate, population, school facilities, manufacturing and business services, and trends in soil use.

Natural Vegetation

The natural vegetation of Union County was mostly grasses. Trees and shrubs grew on the breaks and lower bottom lands of the Big Sioux and Missouri Rivers. Native grasses were mainly big bluestem, blue grama, green needlegrass, indiangrass, switchgrass, and western wheatgrass. Native trees were mostly boxelder, eastern cottonwood, and willow. Only a few acres of natural vegetation remain. These are mainly on the more poorly drained bottoms and on some breaks adjacent to the bottoms of the Big Sioux River.

Relief

The valleys of the Big Sioux and Missouri Rivers merge several miles north of Elk Point and make up an area of about 225 square miles. The elevation ranges from less than 1,100 feet to about 1,200 feet. The bottoms of the Big Sioux River are subject to flooding, but large dams on the Missouri River protect most of these bottoms. Slopes are level and nearly level.

The relief in much of the northern part of the county is rolling, and the drainage pattern is well defined. Slopes are mostly long and smooth and range from 2 to 30 percent. Steeper areas are on the sides of the Big Sioux River Valley and its tributaries. The elevation in this area ranges from 1,250 to 1,450 feet.

The uplands on the western side of the county are mostly nearly level to gently undulating. Slopes are short and are broken by numerous small depressions and narrow swales. The elevation ranges from about 1,320 to 1,500 feet in the northwestern corner of the county. Natural drainage is poorly defined in this area.

Water

Ground water reservoirs in Union County make up a large and reliable source of water for domestic, industrial, stock, and municipal use. All areas of the county are underlain by one or more aquifers that yield small to very large supplies of water. The quality of water varies, but most of the ground water from wells and aquifers has a high content of dissolved minerals.

The largest reservoir of ground water in the county is in the sandy and gravelly glacial outwash deposits (*5*). These deposits underlie the recent alluvial sediment in the valleys of the Big Sioux River, the Missouri River, and many other streams. This reservoir is the source of high yielding wells for irrigation and public water supplies. The depth of these wells ranges from 40 to 125 feet.

Abundant water is also present in the recent alluvial deposits of most stream valleys in the county. Shallow wells 10 to 40 feet deep serve many of the farms in the valleys of the Big Sioux and Missouri Rivers, but an adequate quantity of water suitable for irrigation or for industrial or municipal use can be difficult to obtain at these shallow depths.

Small quantities of water are in stratified sand lenses in glacial till. Enough water for domestic and livestock use can be obtained from these small reservoirs, but the volume of water is generally not enough for irrigation or public water supplies.

Deep artesian aquifers are another large source of ground water (*9*). These aquifers are in the sandstones of the Dakota Formation. The wells penetrating this formation range from 300 to 1,400 feet in depth. They provide water for domestic and livestock use on many of the farms in the northern half of the county. Much of the artesian water, however, is not suitable for irrigation because of its poor chemical quality.

Figure 18.—**McCook Lake in the Albaton-Haynie-Onawa association.**

Surface water in the county includes perennial streams; small, manmade reservoirs; and McCook Lake (fig. 18). Some water for irrigation is taken from the Missouri and Big Sioux Rivers. These surface waters also are used for fishing, boating, and water skiing.

Climate [6]

Union County has a continental climate that is characterized by cold winters and hot summers. Precipitation is generally light in winter and occurs as snow. About 78 percent of the annual precipitation falls during the growing season.

This climatic summary is based on data compiled by the National Oceanic and Atmospheric Administration in Vermillion, South Dakota, 8 miles west of Union County. Union County has no long-term recording station. Weather data taken at Hawarden, Iowa, east of Union County, agrees with the data taken at Vermillion. The elevation of the station at Vermillion is 1,190 feet above sea level, which is typical of Union County except for some hills in the northern part where the elevation ranges to 1,490 feet.

The temperature in the county is 90° F or higher on an average of 36 days a year. Temperatures above 100° occur 3 times a year. The warmest month recorded was July 1955 when the average maximum temperature was 92.5° and the average minimum was 67.3°. In winter the temperature drops to −20° or lower about once a year. The coldest month recorded was January 1963 when the average maximum temperature was 22.8° and the average minimum was −1.9°. The temperature drops below 0° on 17 days a year.

Table 10 gives the probability of specified temperatures after certain dates in spring and fall. This table shows that the probability of a 32° F temperature occurring after May 4 is 50 percent. In other words, in about 5 years out of 10 a temperature of 32° F occurs on or after May 4. Similarly, table 10 shows that the probability of a 32° F temperature occurring on or before October 5 is 50 percent. Based on these two dates, the average growing season is 154 days.

Other data on temperature and precipitation are given by month in table 11. The least amount of precipitation in a year—12.76 inches—was recorded in 1956, and the greatest amount—38.60 inches—was recorded in 1951. Precipitation in the growing season has ranged from 10.27 inches in 1956 to 30.29 inches in 1951. Most of the rainfall during the growing season comes from thunderstorms of widely differing intensity. About once a year 1.25 inches of rain falls in 1 hour, and about once in 5 years 2 inches of rain falls in 1 hour. At least once a year 2 inches of rain falls in 24 hours, and about once in 5 years 3.5 inches of rain falls in 24 hours.

The average annual snowfall at Vermillion is 22.7 inches. Snow protects fields and pastures, but a heavy cover of snow generally delays fieldwork in spring. The least amount of snow during the 1941–70 period was 10.9 inches in 1967–68. The greatest snowfall was in the winter of 1968–69 when 51.3 inches was recorded. The greatest snowfall in one day was 12 inches on December 22, 1968. Strong winds in winter cause snow cover to be deeper in sheltered places and less deep on open fields that have little or no vegetation or crop residue.

About 60 percent of the possible sunshine can be expected in an average year. In July or August 75 percent can be expected.

Windspeed averages 12.5 miles per hour in the summer, and the prevailing direction is south. During winter the wind averages 11 miles per hour, and the prevailing direction is northwest. A windspeed of more than 50 miles per hour can occur during any month of the year, but it is more likely to occur in the summer during thunderstorms. Thunderstorms occur on about 40 to 45 days a year. Hail occasionally accompanies the thunderstorms and can be expected 3 days a year. Hail is most likely to fall in June.

The relative humidity differs widely from early morning to afternoon and from day to day. The annual average humidity is 80 percent in the morning and 60 percent in the afternoon.

The potential water loss from soil and crops is indicated by the loss of water from an evaporation pan. The average annual evaporation from a National Weather Service standard class A pan is 52 inches, 41 inches of which evaporates from May through October. The average annual evaporation rate from small lakes is about 39 inches, and the loss from soil and crops is generally less, depending on the available moisture.

Cultural Features

Union County was created as Cole County in 1862 by the first legislature of Dakota Territory. In 1863 the county was renamed Union County, and its current boundaries were fixed.

According to the U.S. Census Bureau, the population of Union County in 1970 was 9,643, a slight decrease from 10,197 in 1960. About 4,710 people lived on farms. Elk Point, the county seat, had a population of 1,372; Beresford, the largest town, had 1,655 people. North Sioux City had a population of 860.

School facilities in the county consist of elementary and high schools in Alcester, Beresford, Elk Point, Jefferson, and North Sioux City. Colleges and universities are located in nearby Sioux Falls and Vermillion in South Dakota and in Sioux City, Iowa. Sioux City and Sioux Falls also are the sites of vocational and business schools.

Interstate highway 29, U.S. highway 77, and State high-

[6] By William F. Lytle, South Dakota State University.

TABLE 10.—*Probability of selected temperatures after specified dates in spring and before specified dates in fall*

[From data recorded at Vermillion, South Dakota, 1941–70]

Probability	Dates for given probability and temperature					
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower	36° F or lower
After specified date in spring:						
90 percent	March 3	March 13	March 21	April 2	April 14	April 24
70 percent	March 11	March 20	March 29	April 9	April 21	May 1
50 percent	March 25	April 3	April 13	April 23	May 4	May 13
30 percent	April 7	April 15	April 27	May 6	May 17	May 25
10 percent	April 14	April 22	May 5	May 14	May 24	May 31
Before specified date in fall:						
10 percent	October 18	October 15	October 6	September 25	September 14	September 2
30 percent	October 27	October 21	October 13	October 2	September 21	September 10
50 percent	November 12	November 3	October 26	October 18	October 5	September 26
70 percent	November 28	November 14	November 7	November 1	October 18	October 11
90 percent	December 7	November 21	November 14	November 9	October 25	October 19

ways 11, 46, 48, and 50 are the main routes for motor transportation. Graveled or hard-surfaced roads are on nearly every section line. Two railroads serve the county. Daily flights of several commercial airlines are available at nearby Sioux City.

The 1963 U.S. Census of Manufacturing reported 8 manufacturing establishments in the county. Public stockyards and packing firms in Sioux City and Sioux Falls provide markets for livestock producers. Auction sales barns are in smaller towns of Union and adjacent counties. Grain elevators in Alcester, Beresford, Elk Point, and Jefferson provide markets for the sale of grain.

Retailers of farm equipment, hardware, and other farm supplies are in most of the towns in the county and also in neighboring Sioux City, Sioux Falls, and Vermillion.

Trends in Soil Use

The U.S. Census of Agriculture in 1890 reported 1,373 farms in the county with an average size of 167 acres. Since then the number of farms has gradually decreased while the average size has increased. In 1969 there were 949 farms, and the average size was 285 acres.

Field crops accounted for about 27 percent of Union County's cash farm income. In terms of value of production in 1967, corn accounted for 65 percent of all field crops produced followed by soybeans with 20 percent.

During the period 1958 to 1971, corn harvested for grain ranged from 80,500 acres in 1958 to 115,300 acres in 1971. Average yield per acre in 1971 was 70 bushels. The acreage planted to soybeans had increased from 11,200 acres in 1951

TABLE 11.—*Temperature and precipitation data*

[Data from Vermillion. Period of record 1941–70]

Month	Temperature		Precipitation							
	Average daily maximum	Average daily minimum	Average monthly total	Maximum monthly total	Minimum monthly total	1 year in 10 will have— Less than—	1 year in 10 will have— More than—	Average total snowfall	Average number of days that have— Snowfall of 1 inch or more	Average number of days that have— Snow depth of 1 inch or more
	°F	*°F*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*	*Inches*		
January	30.4	7.9	0.47	1.50	0.04	0.10	0.97	4.4	2	14
February	35.7	13.0	.85	2.45	0	.11	1.87	6.6	2	13
March	44.8	22.8	1.16	3.42	.10	.33	2.22	6.8	3	11
April	63.3	37.0	2.21	5.09	.24	.75	4.02	.5	(1)	(1)
May	74.1	48.0	3.74	7.87	1.00	1.73	6.11	.1	(1)	(1)
June	82.8	58.2	4.28	7.23	1.09	2.03	6.91	0	0	0
July	88.0	62.8	3.38	7.48	.66	1.30	5.92	0	0	0
August	86.7	61.0	3.18	8.19	.19	.83	6.18	0	0	0
September	77.2	50.7	2.57	7.38	.36	.85	4.72	0	0	0
October	67.2	39.9	1.57	6.01	0	.11	3.57	.2	(1)	(1)
November	48.9	25.6	.85	2.84	0	.08	1.94	2.9	1	3
December	35.0	14.0	.67	2.58	0	.08	1.47	6.2	2	11
Year	61.1	37.0	24.93	[2] 38.60	[3] 12.76	18.08	32.66	27.7	10	55

[1] Less than one-half day. [2] In 1951. [3] In 1956.

to 41,500 acres in 1971. In 1971 the average yield per acre of soybeans was 24.5 bushels. The acreage planted to oats had steadily decreased during those 20 years. In 1971 oats were planted on 26,500 acres, and the average yield per acre was 58 bushels. Alfalfa grown for hay had also declined. In 1971 alfalfa was harvested for hay on 8,600 acres, and the average yield per acre was 3.2 tons. Minor amounts of barley, sorghum, and wheat also were grown.

In 1959 irrigated crops were harvested on 1,723 acres. This increased to 3,210 acres in 1970. Corn and alfalfa were the main irrigated crops.

The sale of livestock and livestock products accounted for about 66 percent of cash farm income in the county. Cattle and swine accounted for most of this income. In 1969 there were 45,003 cattle, 55,776 hogs, 4,697 sheep, and 50,965 chickens on farms. The number of cattle included 2,315 cows kept for milk production. The number of cattle raised for beef production has steadily increased during the past 40 years; the number of hogs has fluctuated according to market conditions; and the number of sheep and chickens has steadily declined.

Additional information on the trends in crop and livestock production can be obtained from the annual reports of the South Dakota Crop and Livestock Reporting Service.

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Bottom land. The normal flood plain of a stream, subject to frequent flooding.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Contour stripcropping (or contour farming). Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the

surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients, as for example in "hillpeats" and "climatic moors."

Erosion. The wearing away of the land surface by running water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes a bare surface.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the assorted and unassorted material deposited by streams flowing from glaciers.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Green manure (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner colors than those in the A horizon; or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—few, common, and many; size—fine, medium, and coarse; and contrast—faint, distinct, and prominent. The size measurements are of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Runoff. The precipitation discharged in stream channels from a drainage area. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Saline soil. A soil containing soluble salts in an amount that impairs growth of plants. A saline soil does not contain excess exchangeable sodium.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows: very coarse sand (2.0 millimeters to 1.0 millimeter); coarse sand (1.0 to 0.5 millimeter); medium sand (0.5 to 0.25 millimeter); fine sand (0.25 to 0.10 millimeter); very fine sand (0.10 to 0.05 millimeter); silt (0.005 to 0.002 millimeter); and clay (less than 0.002 millimeter).

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Stratified. Arranged in strata, or layers. The term refers to geologic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are—platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsurface layer. Technically, the A2 horizon. Generally refers to a leached horizon lighter in color and lower in content of organic matter than the overlying surface layer.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it can soak into the soil or flow slowly to a prepared outlet without harm. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. A stream terrace is frequently called a second bottom, in contrast with a flood plain, and is seldom subject to overflow. A marine terrace, generally wide, was deposited by the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Water table. The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Water table, artesian. A water table under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

Absence of a capability unit, pasture group, or windbreak group designation indicates that the mapping unit is not placed in a specified grouping or that the individual soils of a mapping unit are designated separately For a full description of a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs.

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page	Pasture group Letter	Windbreak group Number
Ab	Albaton silt loam, overwash	9	IIw-1	42	A	2
Ac	Albaton silty clay	9	IIIw-2	44	A	2
Ad	Albaton silty clay, depressional	9	Vw-2	46	B	10
Ae	Alcester silt loam, 2 to 6 percent slopes	10	IIe-1	42	K	1
Bd	Benclare silty clay loam, somewhat poorly drained	11	IIw-1	42	A	2
Be	Benclare soils, overwash	11	IIw-1	42	A	2
Bf	Blencoe silty clay	11	IIw-1	42	A	2
Bg	Blyburg silt loam	12	I-1	41	F	3
Ca	Calco silty clay loam, wet	12	IVw-2	46	B	2
CbE2	Crofton silt loam, 12 to 17 percent slopes, eroded	14	VIe-3	46	G	10
CbF	Crofton silt loam, 17 to 30 percent slopes	14	VIe-3	46	G	10
CnB	Crofton-Nora silt loams, 2 to 6 percent slopes	14	-------	--	---	--
	Crofton part	--	IIIe-6	43	G	8
	Nora part	--	IIe-3	42	F	3
CnD2	Crofton-Nora silt loams, 6 to 12 percent slopes, eroded	14	IVe-2	45	--	--
	Crofton part	--	-------	--	G	8
	Nora part	--	-------	--	F	3
Da	Davis loam	16	I-1	41	K	1
De	Dempster silty clay loam	16	IIs-3	43	D	6
EaB	Egan-Shindler complex, 2 to 6 percent slopes	18	-------	--	--	3
	Egan part	--	IIe-3	42	F	--
	Shindler part	--	IIIe-6	43	G	--
EaC	Egan-Shindler complex, 6 to 9 percent slopes	18	-------	--	--	3
	Egan part	--	IIIe-2	43	F	--
	Shindler part	--	IVe-2	45	G	--
EmA	Enet loam, 0 to 2 percent slopes	19	IIs-3	43	D	6
EnB	Enet and Dempster soils, 2 to 6 percent slopes	19	IIIs-2	44	D	6
Fa	Fluvaquents	19	IVw-2	46	A	2
Fb	Fluvaquents, wet	19	-------	--	--	10
	Where grazable	--	Vw-2	46	--	--
	Where nongrazable	--	VIIIw-1	47	--	--
Fc	Forney silty clay	20	IIIw-2	44	A	2
Fe	Forney soils, overwash	21	IIw-1	42	A	2
Ga	Grable silt loam	21	IIs-3	43	D	6
Gb	Graceville silty clay loam	22	I-3	42	K	1
Ha	Haynie silt loam	22	I-1	41	F	1
Hb	Haynie silty clay loam	22	I-1	41	F	1
Ja	James silty clay	23	IVw-2	46	J	10
Ka	Kennebec silty clay loam	24	I-1	41	K	1
La	Lakeport silty clay loam	25	IIw-1	42	A	2
Lb	Lamo silty clay loam	26	IIw-3	43	A	2
Ld	Luton silty clay	26	IIIw-2	44	A	2
Ma	McPaul silt loam	27	I-1	41	F	1
Mb	Modale silt loam	28	I-1	41	K	1
McA	Moody silty clay loam, 0 to 2 percent slopes	28	I-2	42	F	3
McB	Moody silty clay loam, 2 to 6 percent slopes	28	IIe-3	42	F	3
MdC	Moody-Nora silty clay loams, 6 to 10 percent slopes	28	IIIe-2	43	F	3
NeF	Nora-Crofton silt loams, 20 to 50 percent slopes	30	-------	--	--	10
	Nora part	--	VIe-1	46	F	--
	Crofton part	--	VIIe-1	47	--	--
Oa	Omadi silt loam	31	I-1	41	F	3
Ob	Onawa silty clay	31	-------	--	--	2
	Where drained	--	IIw-3	43	A	--
	Where not drained	--	IVw-2	46	B	--

Map symbol	Mapping unit	Page	Capability unit Symbol	Capability unit Page	Pasture group Letter	Windbreak group Number
Pa	Percival silty clay	32	IIw-3	43	A	2
Sa	Salix silty clay loam	32	I-1	41	F	3
Sb	Salmo silty clay loam, somewhat poorly drained	33	IIIw-3	44	J	10
ScB	Sarpy loamy fine sand, 3 to 9 percent slopes	34	VIs-1	47	H	7
SdA	Sarpy silty clay overwash, 0 to 1 percent slopes	34	IVs-1	46	H	7
SeA	Sarpy soils, 0 to 3 percent slopes	34	IVs-1	46	H	7
ShD	Shindler clay loam, 9 to 15 percent slopes	35	VIe-3	46	G	10
ShE	Shindler clay loam, 15 to 30 percent slopes	35	VIe-3	46	G	10
St	Storla loam	36	IIIs-4	44	D	1
TaB	Thurman fine sandy loam, 3 to 9 percent slopes	36	IVe-3	45	H	5
Wa	Wakonda-Worthing-Chancellor complex	37	-------	--	--	--
	Wakonda part	--	IIe-4	42	F	1
	Worthing part	--	-------	--	--	10
	Where drained	--	IIIw-1	44	A	--
	Where not drained	--	Vw-2	46	B	--
	Chancellor part	--	IIw-1	42	A	2
WbA	Wentworth silty clay loam, 0 to 2 percent slopes	38	I-2	42	F	3
WbB	Wentworth silty clay loam, 2 to 6 percent slopes	38	IIe-3	42	F	3
Wc	Wentworth-Worthing silty clay loams	38	-------	--	--	--
	Wentworth part	--	I-2	42	F	3
	Worthing part	--	-------	--	--	10
	Where drained	--	IIIw-1	44	A	--
	Where not drained	--	Vw-2	46	B	--
Wh	Whitewood silty clay loam	39	-------	--	--	2
	Where drained	--	IIw-2	43	A	--
	Where not drained	--	IVw-2	46	B	--
Wo	Worthing silty clay loam	39	-------	--	--	10
	Where drained	--	IIIw-1	44	A	--
	Where not drained	--	Vw-2	46	B	--
Ws	Worthing-Chancellor silty clay loams	39	-------	--	--	--
	Worthing part	--	-------	--	--	10
	Where drained	--	IIIw-1	44	A	--
	Where not drained	--	Vw-2	46	B	--
	Chancellor part	--	IIw-1	42	A	2

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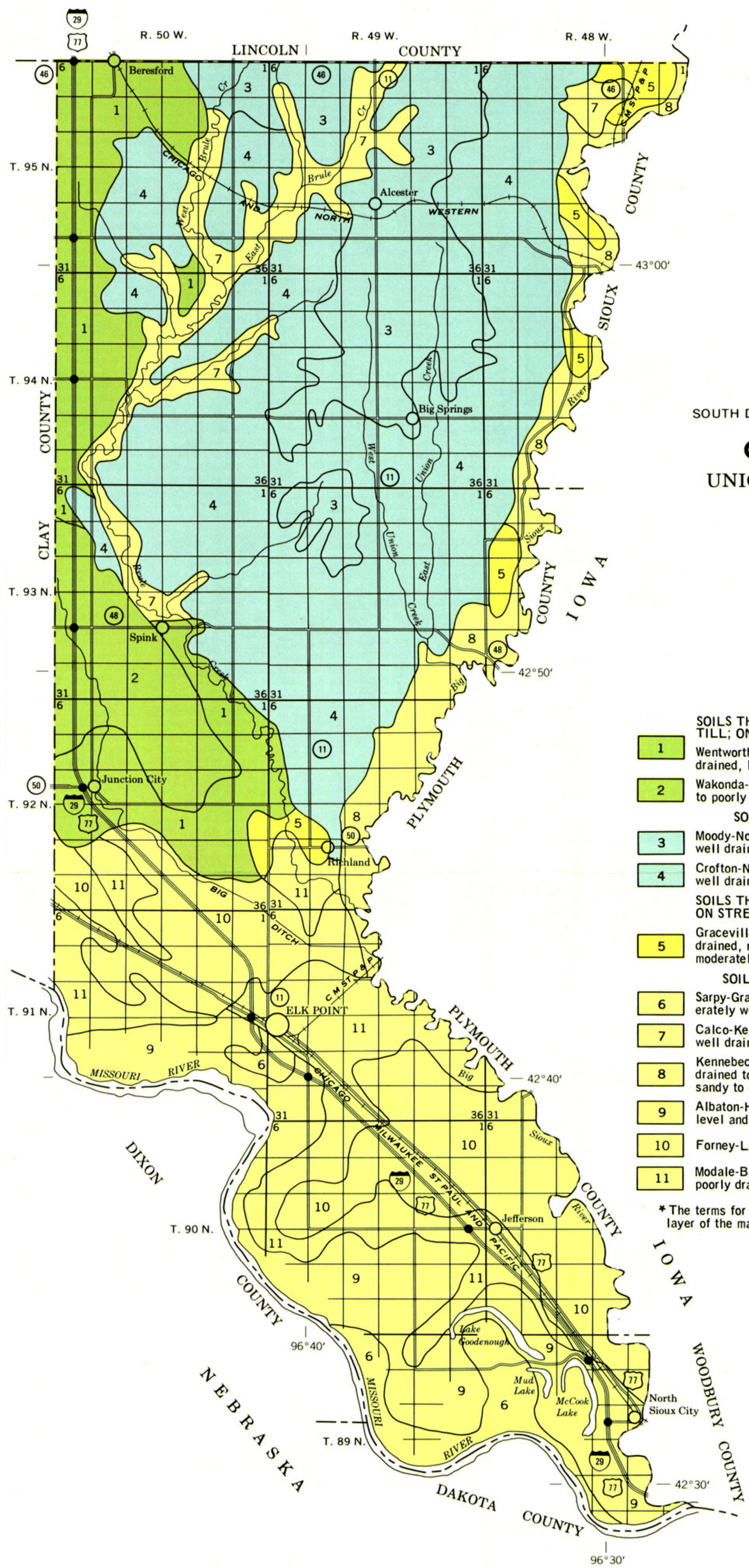


U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
SOUTH DAKOTA AGRICULTURAL EXPERIMENT STATION

GENERAL SOIL MAP

UNION COUNTY, SOUTH DAKOTA

Scale 1:190,080

1 0 1 2 3 4 Miles

SOIL ASSOCIATIONS*

SOILS THAT FORMED MOSTLY IN GLACIAL DRIFT AND GLACIAL TILL; ON UPLANDS

1 Wentworth-Shindler-Worthing association: Deep, well drained and poorly drained, level to steep, silty and loamy soils

2 Wakonda-Worthing-Chancellor association: Deep, moderately well drained to poorly drained, nearly level and level, silty soils

SOILS THAT FORMED MOSTLY IN LOESS; ON UPLANDS

3 Moody-Nora-Alcester association: Deep, well drained and moderately well drained, nearly level to sloping, silty soils

4 Crofton-Nora-Alcester association: Deep, well drained and moderately well drained, gently sloping to very steep, silty soils

SOILS THAT FORMED IN ALLUVIUM OVERLYING GRAVELLY SAND; ON STREAM TERRACES

5 Graceville-Dempster association: Moderately well drained and well drained, nearly level to gently sloping, silty soils that are deep and moderately deep over gravelly sand

SOILS THAT FORMED IN ALLUVIUM; ON BOTTOM LANDS

6 Sarpy-Grable-Haynie association: Deep, excessively drained to moderately well drained, level to undulating, sandy and silty soils

7 Calco-Kennebec association: Deep, poorly drained and moderately well drained, level and nearly level, silty soils

8 Kennebec-Fluvaquents-Benclare association: Deep, moderately well drained to very poorly drained, level and nearly level, silty and mixed sandy to clayey soils

9 Albaton-Haynie-Onawa association: Deep, poorly drained to well drained, level and nearly level, clayey and silty soils

10 Forney-Luton association: Deep, poorly drained, level, clayey soils

11 Modale-Blyburg-Benclare association: Deep, well drained to somewhat poorly drained, nearly level and level, silty soils

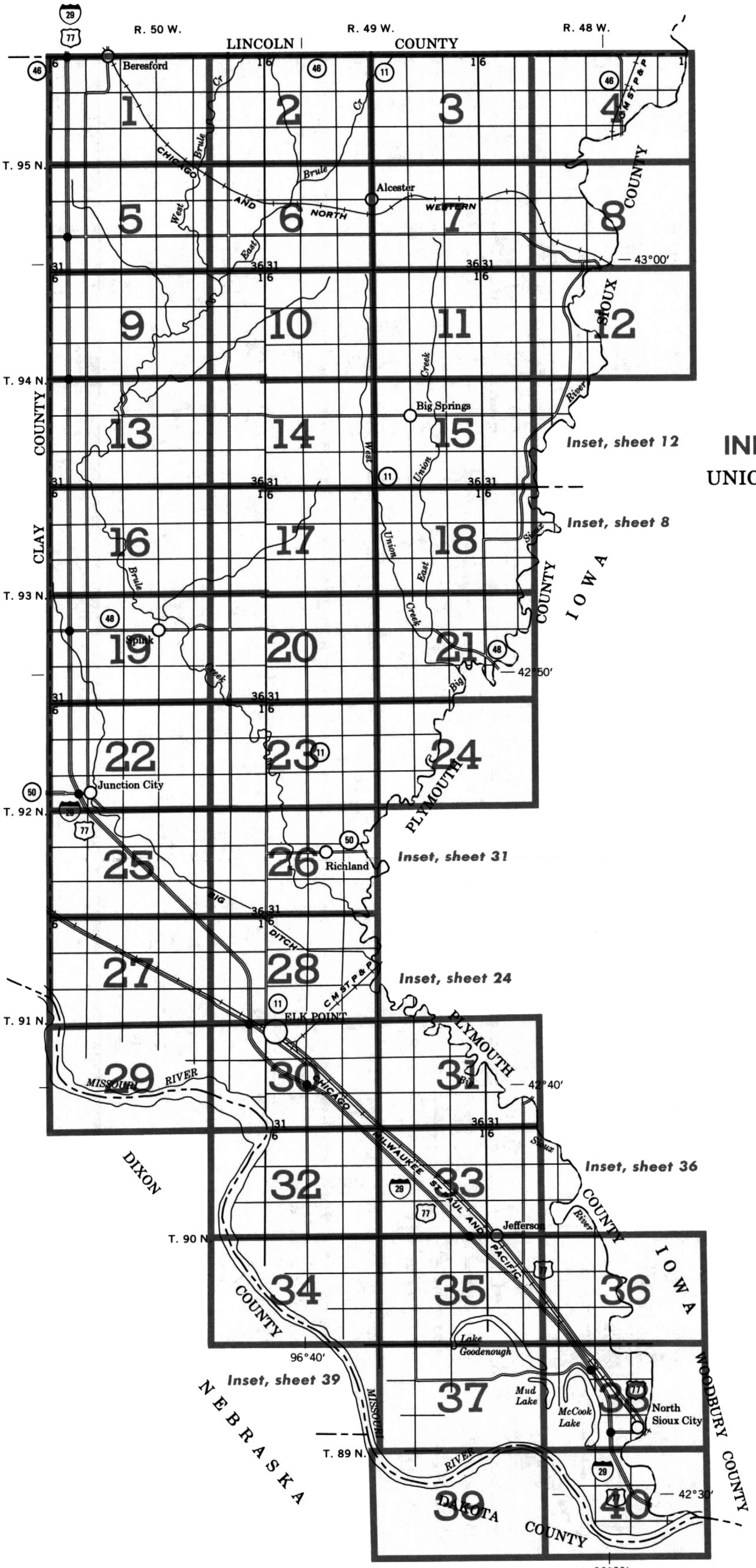
*The terms for texture used in the descriptive headings apply to the surface layer of the major soils in each association.

Compiled 1977

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

Each area outlined on this map consists of more than one kind of soil. The map is thus meant for general planning rather than a basis for decisions on the use of specific tracts.



INDEX TO MAP SHEETS
UNION COUNTY, SOUTH DAKOTA

Scale 1:190,080

1 0 1 2 3 4 Miles

SECTIONALIZED TOWNSHIP

6	5	4	3	2	1
7	8	9	10	11	12
18	17	16	15	14	13
19	20	21	22	23	24
30	29	28	27	26	25
31	32	33	34	35	36

CONVENTIONAL AND SPECIAL SYMBOLS LEGEND

CULTURAL FEATURES

BOUNDARIES

- National, state or province
- County or parish
- Minor civil division
- Reservation (national forest or park, state forest or park, and large airport)
- Land grant
- Limit of soil survey (label)
- Field sheet matchline & neatline

AD HOC BOUNDARY (label)

- Small airport, airfield, park, oilfield, cemetery, or flood pool — Davis Airstrip; FLOOD POOL LINE

STATE COORDINATE TICK

LAND DIVISION CORNERS (sections and land grants)

ROADS

- Divided (median shown if scale permits)
- Other roads
- Trail

ROAD EMBLEMS & DESIGNATIONS

- Interstate — 79
- Federal — 410
- State — 52
- County, farm or ranch — 378

RAILROAD

POWER TRANSMISSION LINE (normally not shown)

PIPE LINE (normally not shown)

FENCE (normally not shown)

LEVEES

- Without road
- With road
- With railroad

DAMS

- Large (to scale)
- Medium or small — water; w

PITS

- Gravel pit — G.P.
- Mine or quarry

MISCELLANEOUS CULTURAL FEATURES

- Farmstead, house (omit in urban areas)
- Church
- School
- Indian mound (label) — Indian Mound
- Located object (label) — Tower
- Tank (label) — GAS
- Wells, oil or gas
- Windmill
- Kitchen midden

WATER FEATURES

DRAINAGE

- Perennial, double line
- Perennial, single line
- Intermittent
- Drainage end
- Canals or ditches
  - Double-line (label) — CANAL
  - Drainage and/or irrigation

LAKES, PONDS AND RESERVOIRS

- Perennial — water; w
- Intermittent — int; i

MISCELLANEOUS WATER FEATURES

- Marsh or swamp
- Spring
- Well, artesian
- Well, irrigation
- Wet spot

SPECIAL SYMBOLS FOR SOIL SURVEY

SOIL DELINEATIONS AND SYMBOLS

CeA FoB2

ESCARPMENTS

- Bedrock (points down slope)
- Other than bedrock (points down slope)

SHORT STEEP SLOPE

GULLY

DEPRESSION OR SINK

SOIL SAMPLE SITE (normally not shown)

S

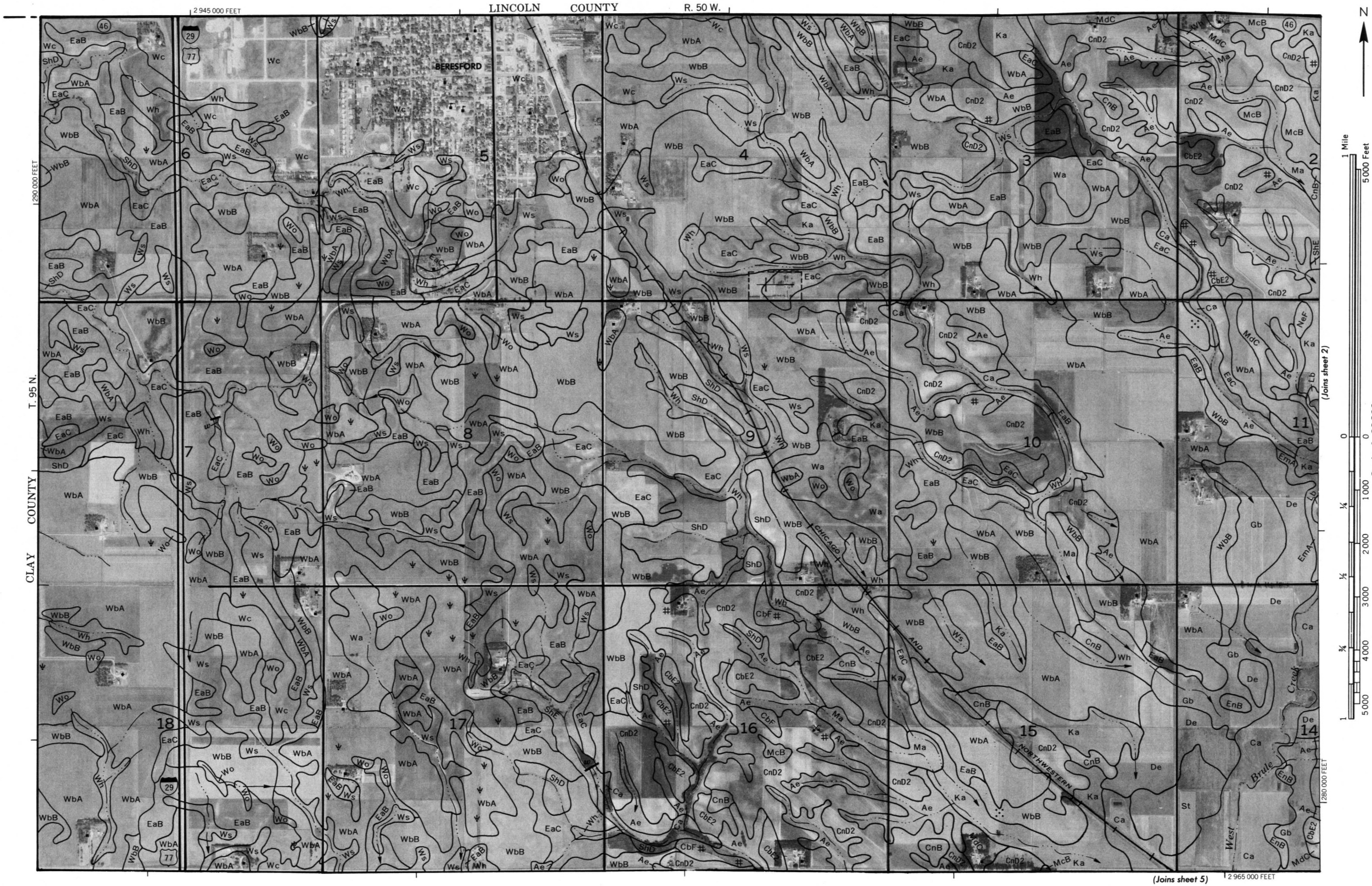
MISCELLANEOUS

- Blowout
- Clay spot
- Gravelly spot
- Gumbo, slick or scabby spot (sodic) — ø
- Dumps and other similar non soil areas
- Prominent hill or peak
- Rock outcrop (includes sandstone and shale)
- Saline spot — +
- Sandy spot
- Severely eroded spot
- Slide or slip (tips point upslope)
- Stony spot, very stony spot
- Glacial till, 2 acres or less — #
- Made land — M.L.
- Borrow pit — B.P.

SOIL LEGEND

Each symbol consists of two or three letters; for example Ab, De, or EaC. If slope is given in the soil name the third letter A, B, C, D, E, or F indicates the class of slope. Symbols without a slope letter are those of nearly level soils. A final number 2 in the symbol indicates that the soil is eroded.

SYMBOL	NAME
Ab	Albaton silt loam, overwash
Ac	Albaton silty clay
Ad	Albaton silty clay, depressional
Ae	Alcester silt loam, 2 to 6 percent slopes
Bd	Benclare silty clay loam, somewhat poorly drained
Be	Benclare soils, overwash
Bf	Blencoe silty clay
Bg	Blyburg silt loam
Ca	Calco silty clay loam, wet
CbE2	Crofton silt loam, 12 to 17 percent slopes, eroded
CbF	Crofton silt loam, 17 to 30 percent slopes
CnB	Crofton-Nora silt loams, 2 to 6 percent slopes
CnD2	Crofton-Nora silt loams, 6 to 12 percent slopes, eroded
Da	Davis loam
De	Dempster silty clay loam
EaB	Egan-Shindler complex, 2 to 6 percent slopes
EaC	Egan-Shindler complex, 6 to 9 percent slopes
EmA	Enet loam, 0 to 2 percent slopes
EnB	Enet and Dempster soils, 2 to 6 percent slopes
Fa	Fluvaquents
Fb	Fluvaquents, wet
Fc	Forney silty clay
Fe	Forney soils, overwash
Ga	Grable silt loam
Gb	Graceville silty clay loam
Ha	Haynie silt loam
Hb	Haynie silty clay loam
Ja	James silty clay
Ka	Kennebec silty clay loam
La	Lakeport silty clay loam
Lb	Lamo silty clay loam
Ld	Luton silty clay
Ma	McPaul silt loam
Mb	Modale silt loam
McA	Moody silty clay loam, 0 to 2 percent slopes
McB	Moody silty clay loam, 2 to 6 percent slopes
MdC	Moody-Nora silty clay loams, 6 to 10 percent slopes
NeF	Nora-Crofton silt loams, 20 to 50 percent slopes
Oa	Omadi silt loam
Ob	Onawa silty clay
Pa	Percival silty clay
Sa	Salix silty clay loam
Sb	Salmo silty clay loam, somewhat poorly drained
ScB	Sarpy loamy fine sand, 3 to 9 percent slopes
SdA	Sarpy silty clay overwash, 0 to 1 percent slopes
SeA	Sarpy soils, 0 to 3 percent slopes
ShD	Shindler clay loam, 9 to 15 percent slopes
ShE	Shindler clay loam, 15 to 30 percent slopes
St	Storla loam
TaB	Thurman fine sandy loam, 3 to 9 percent slopes
Wa	Wakonda-Worthing-Chancellor complex
WbA	Wentworth silty clay loam, 0 to 2 percent slopes
WbB	Wentworth silty clay loam, 2 to 6 percent slopes
Wc	Wentworth-Worthing silty clay loams
Wh	Whitewood silty clay loam
Wo	Worthing silty clay loam
Ws	Worthing-Chancellor silty clay loams



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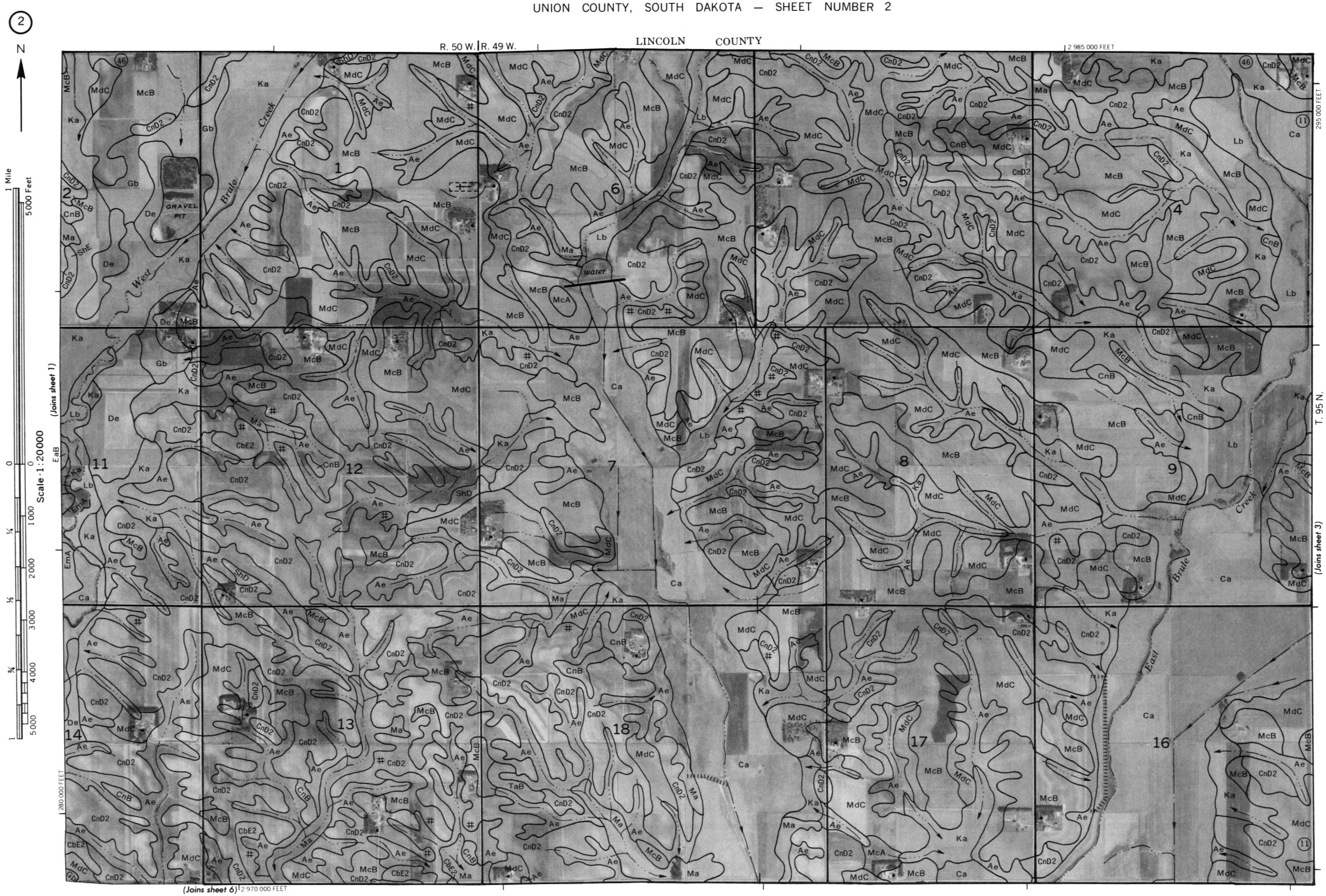
UNION COUNTY, SOUTH DAKOTA NO. 1

UNION COUNTY, SOUTH DAKOTA — SHEET NUMBER 2



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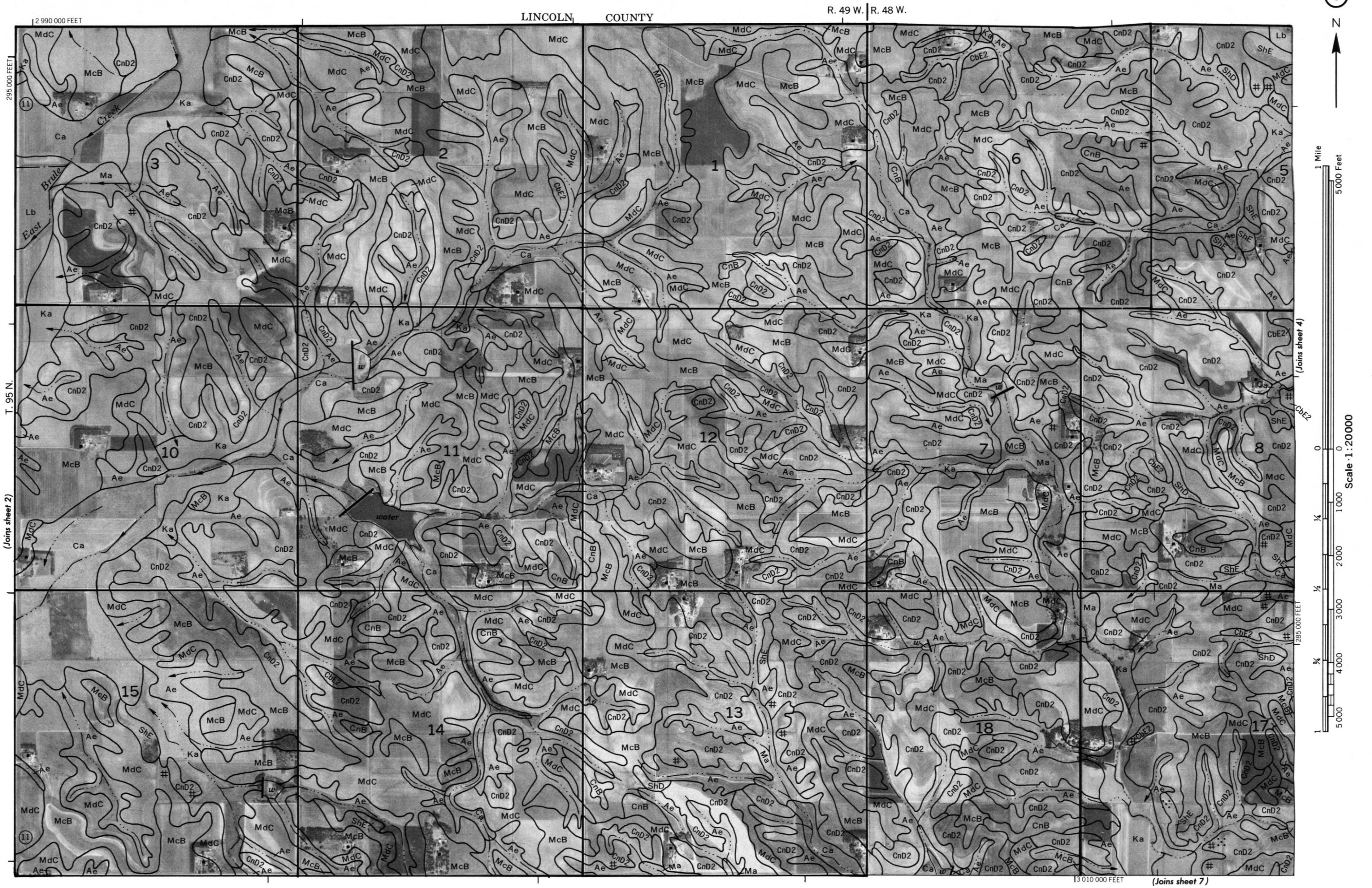

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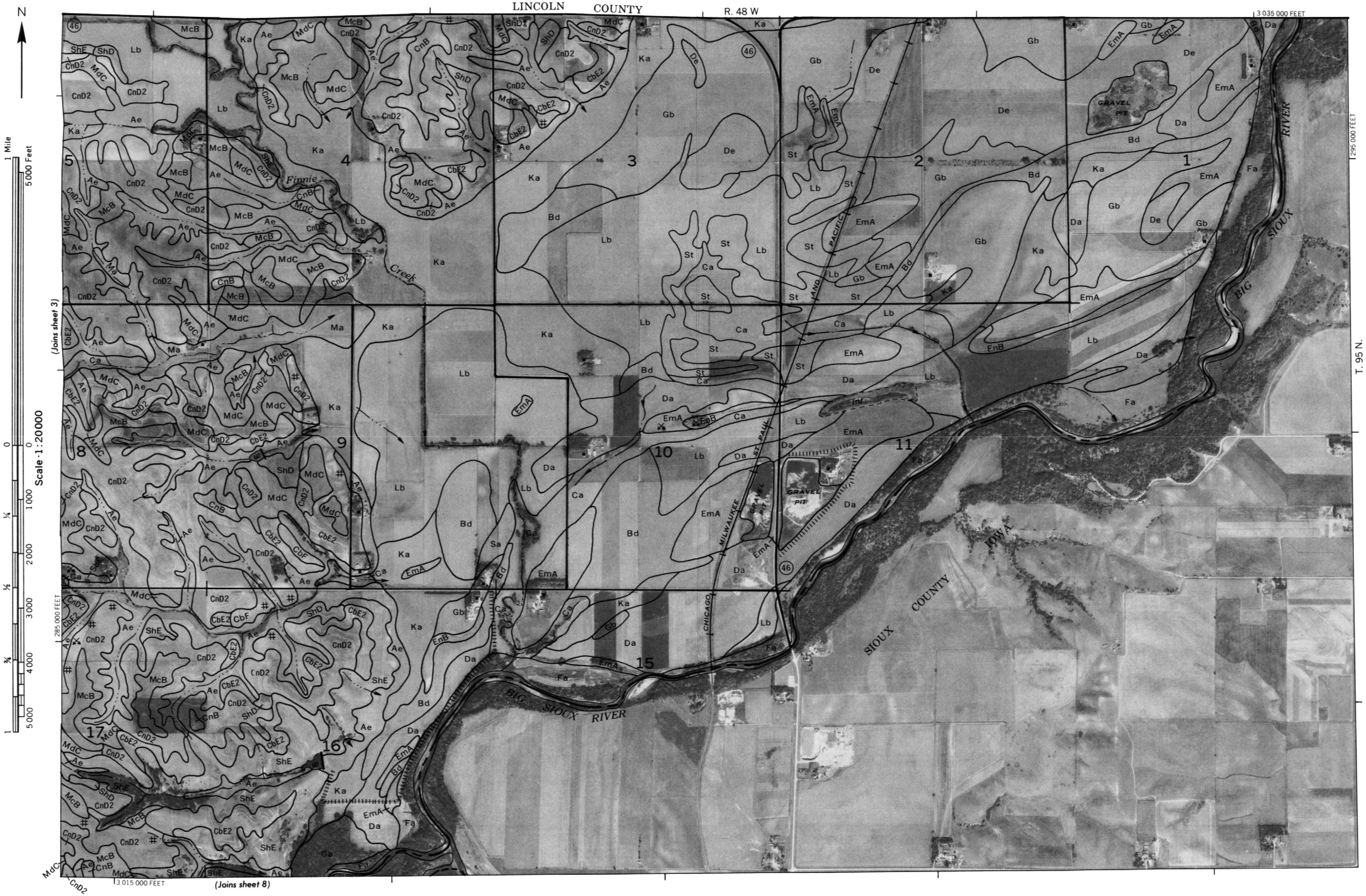

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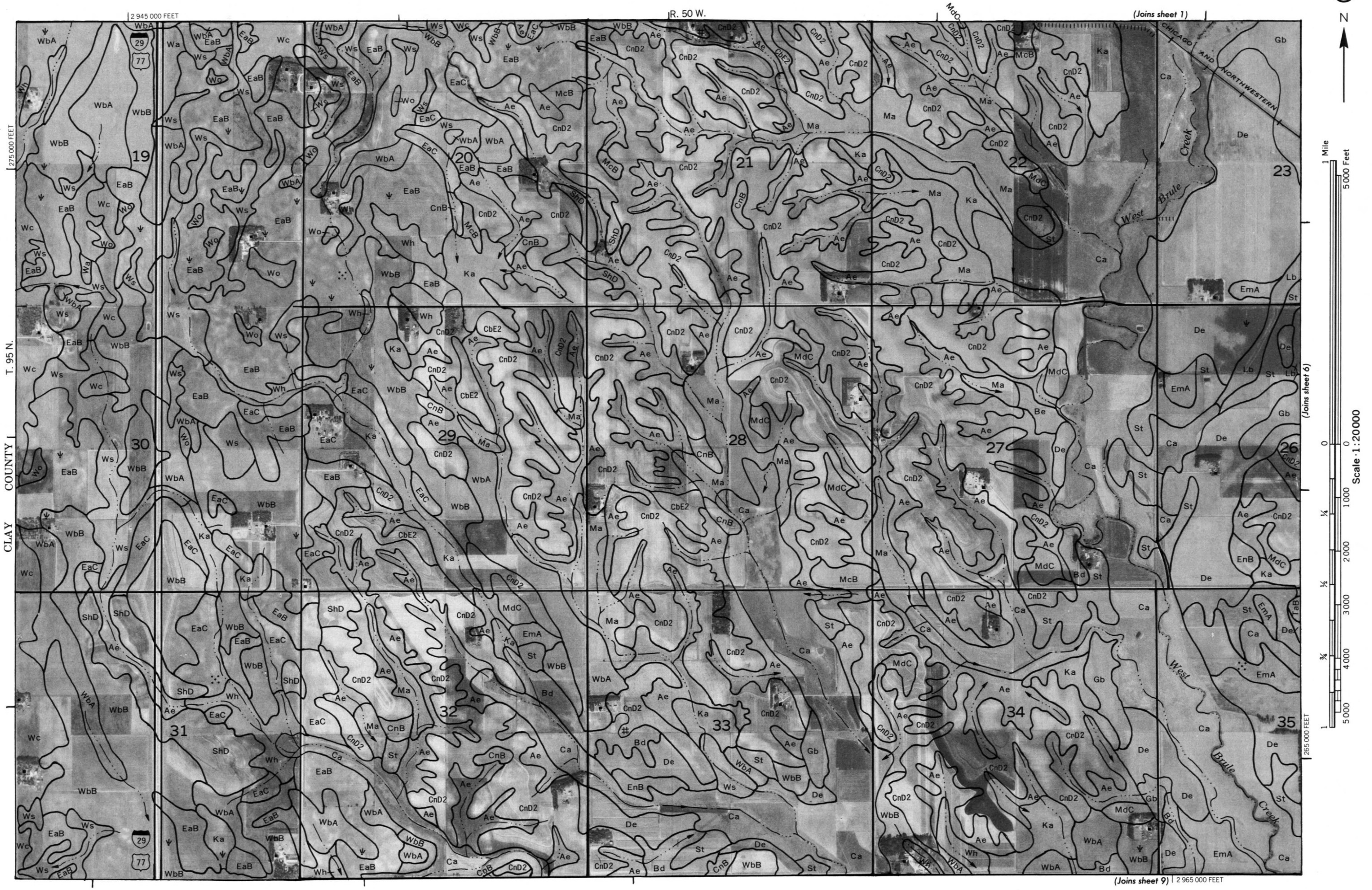
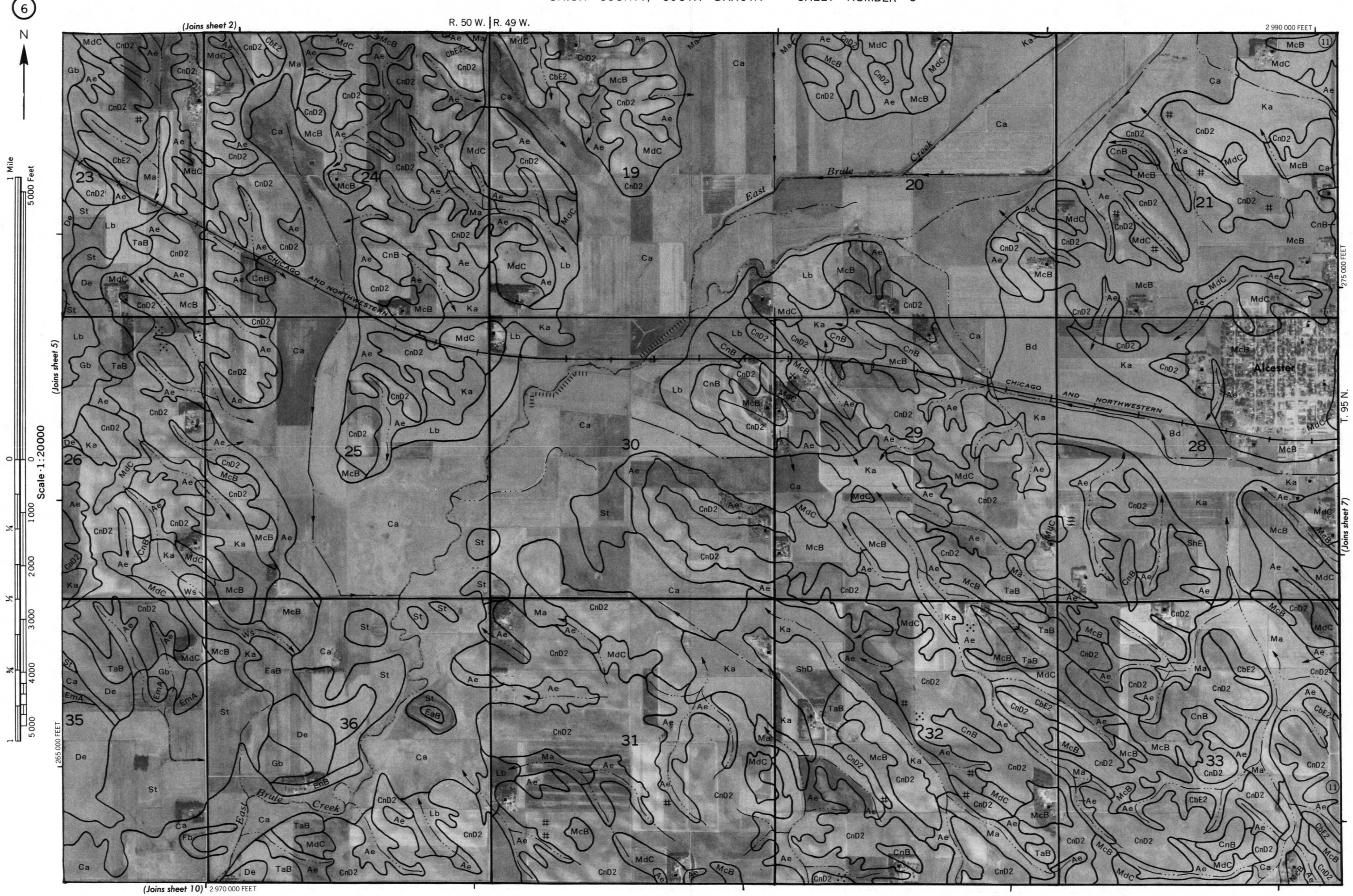
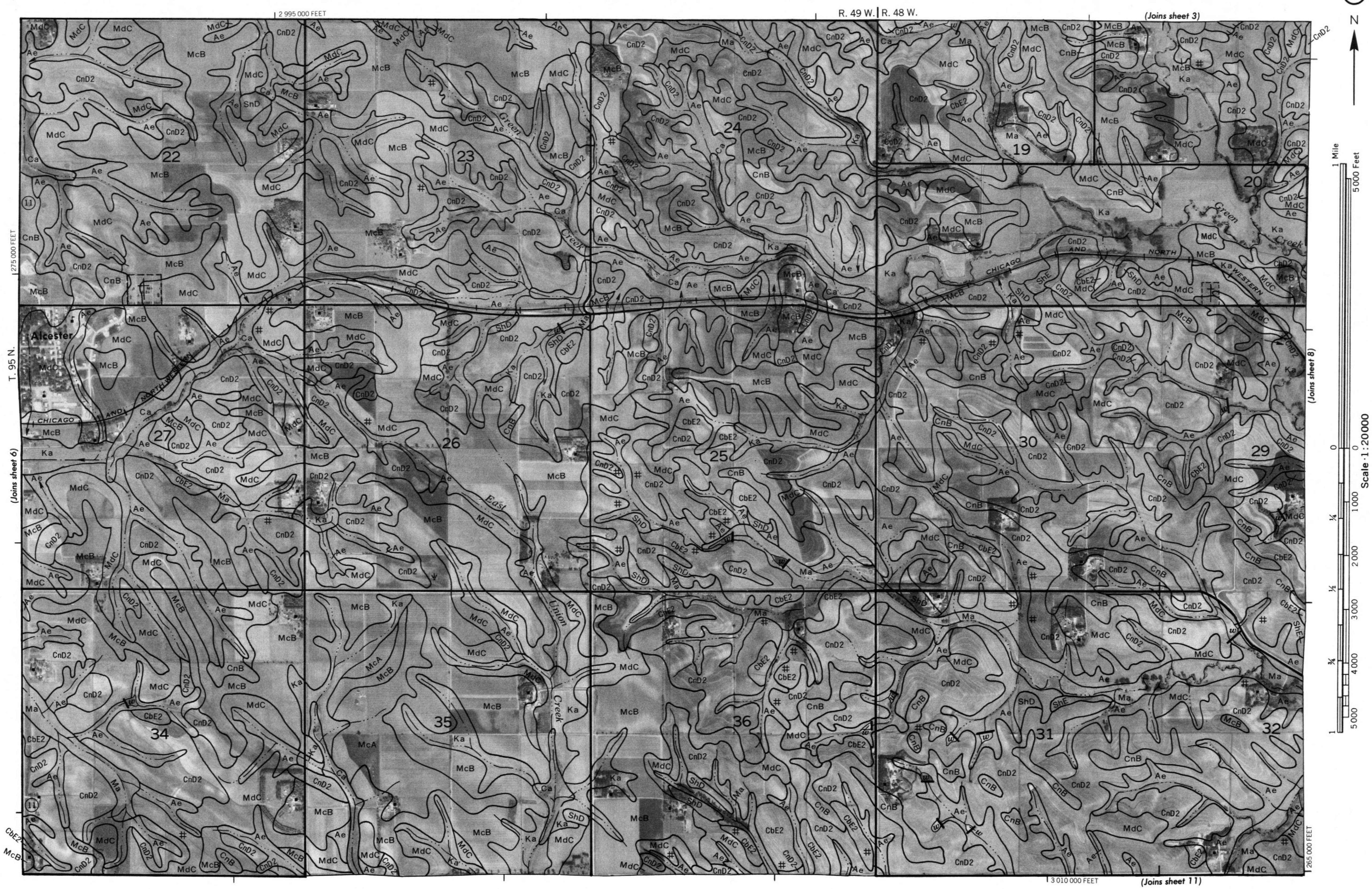
UNION COUNTY, SOUTH DAKOTA NO. 4



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.
UNION COUNTY, SOUTH DAKOTA NO. 5



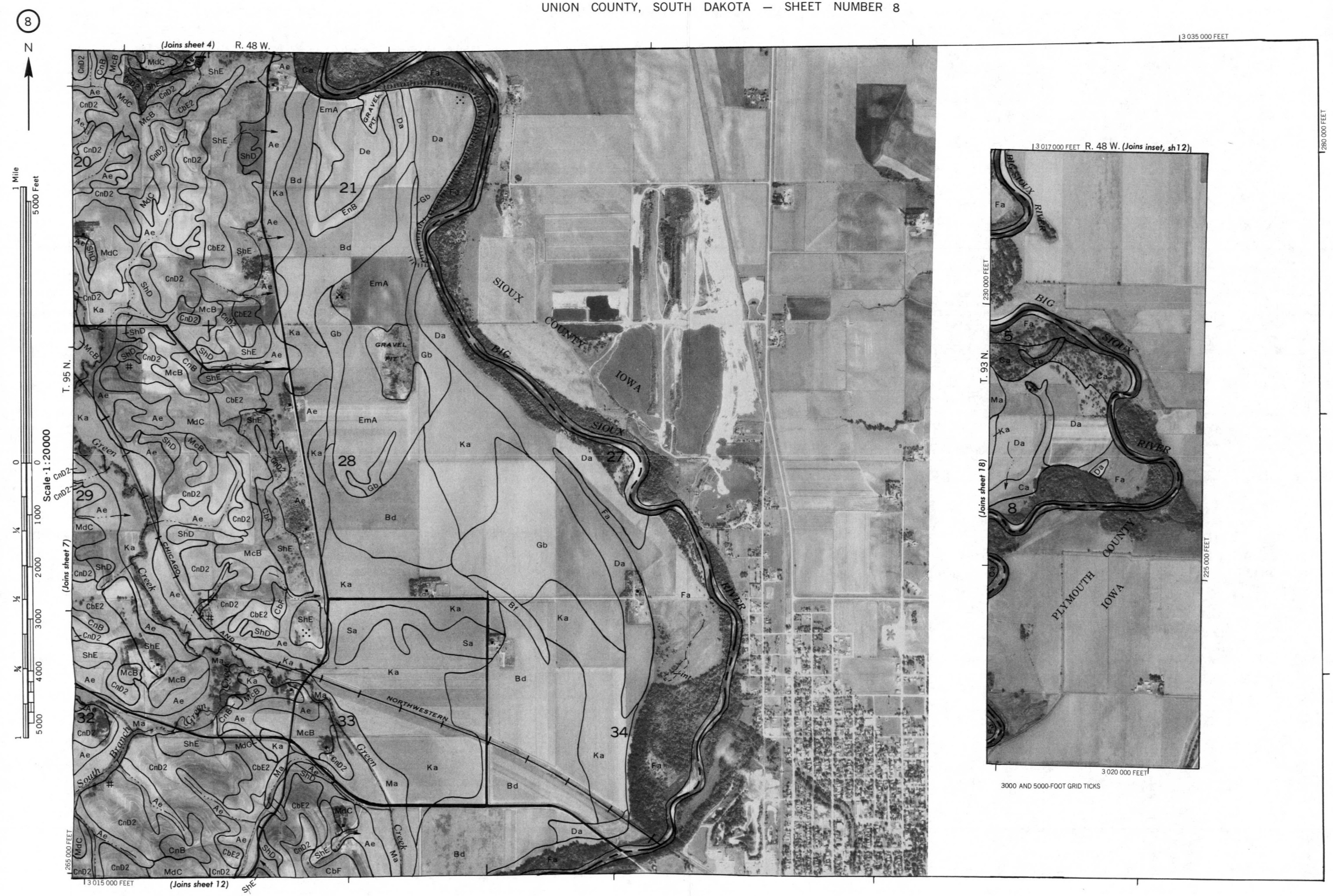
This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

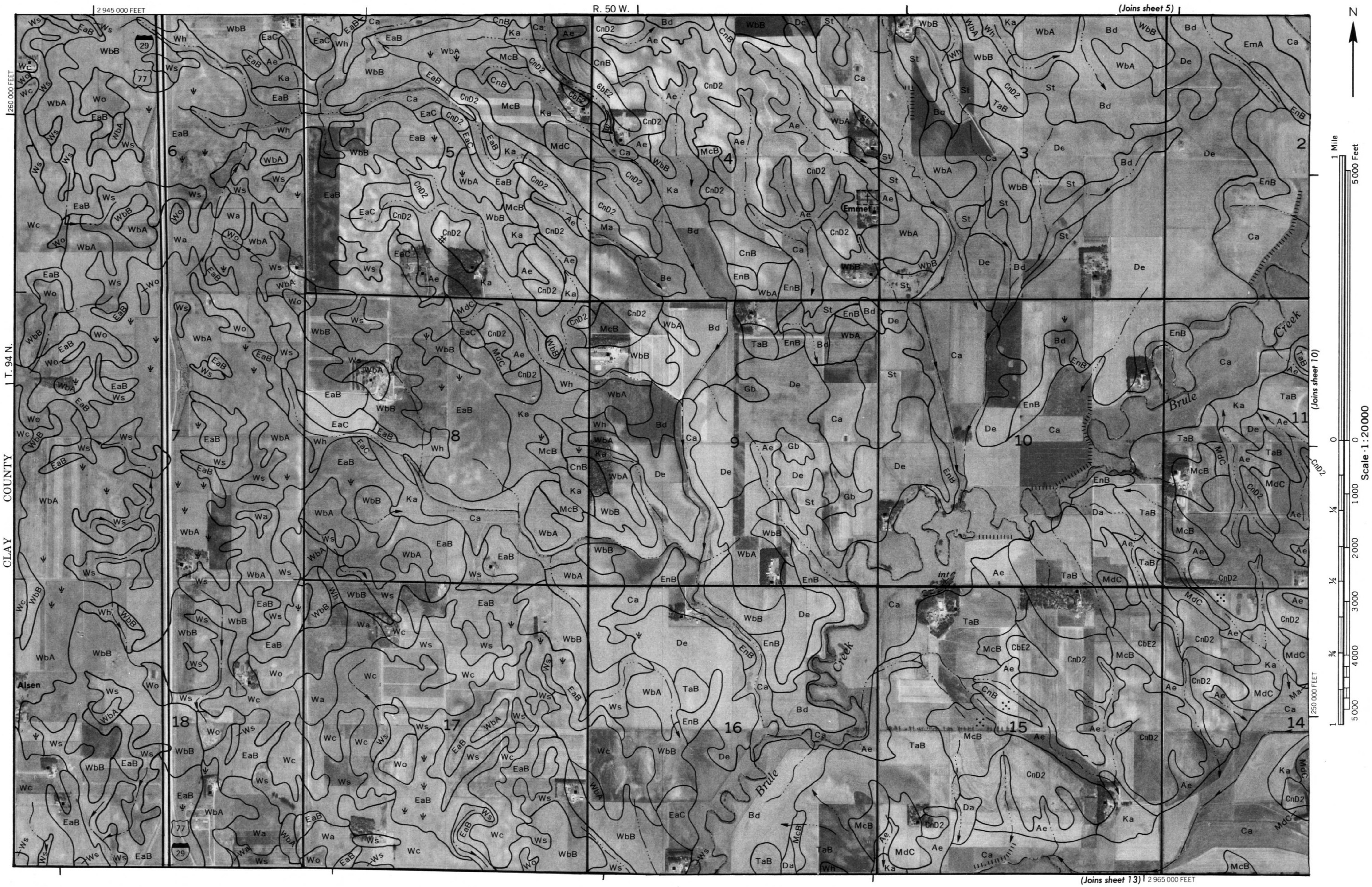
UNION COUNTY, SOUTH DAKOTA NO. 7

UNION COUNTY, SOUTH DAKOTA — SHEET NUMBER 8



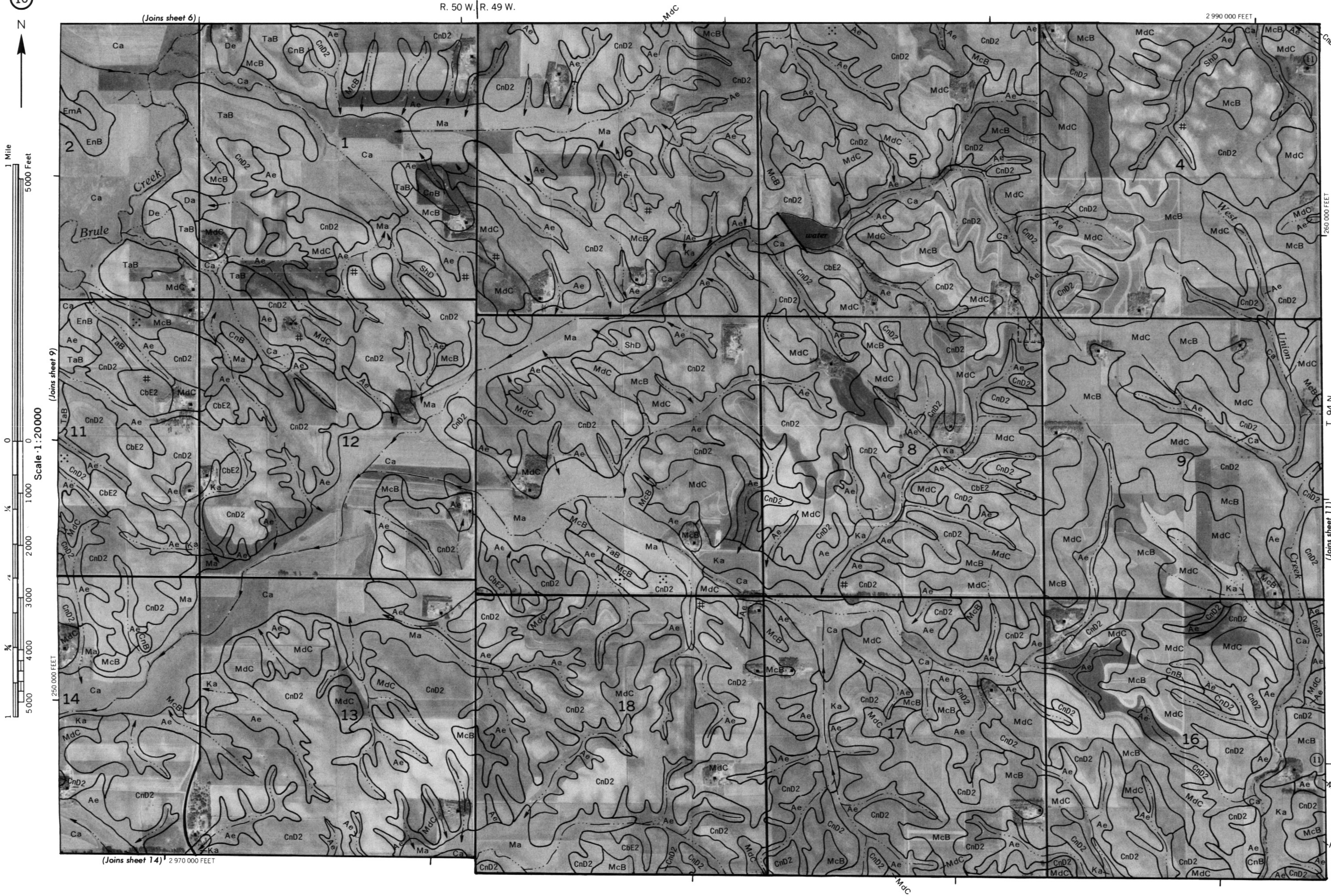
This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

9



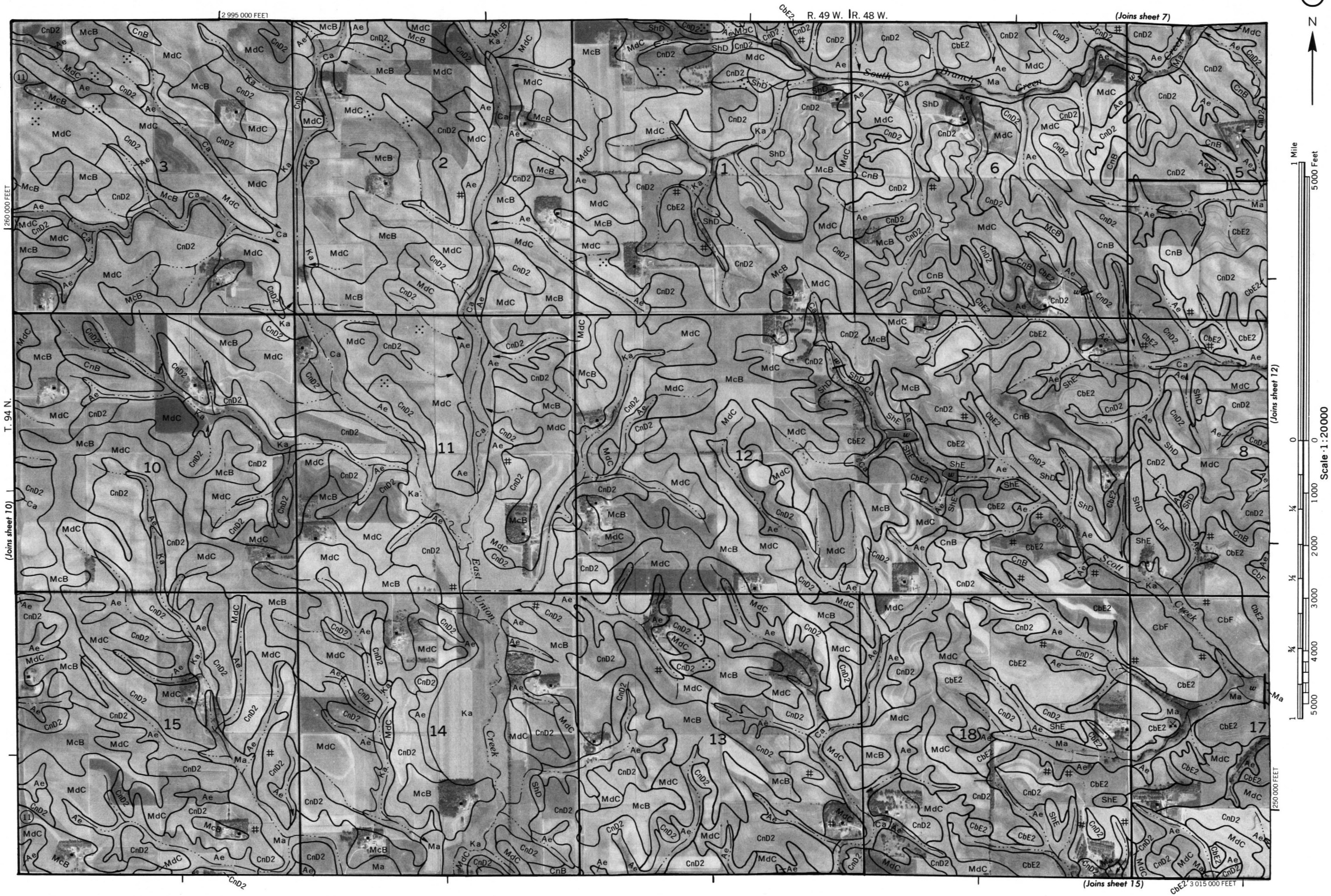
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.
UNION COUNTY, SOUTH DAKOTA NO. 9

UNION COUNTY, SOUTH DAKOTA — SHEET NUMBER 10

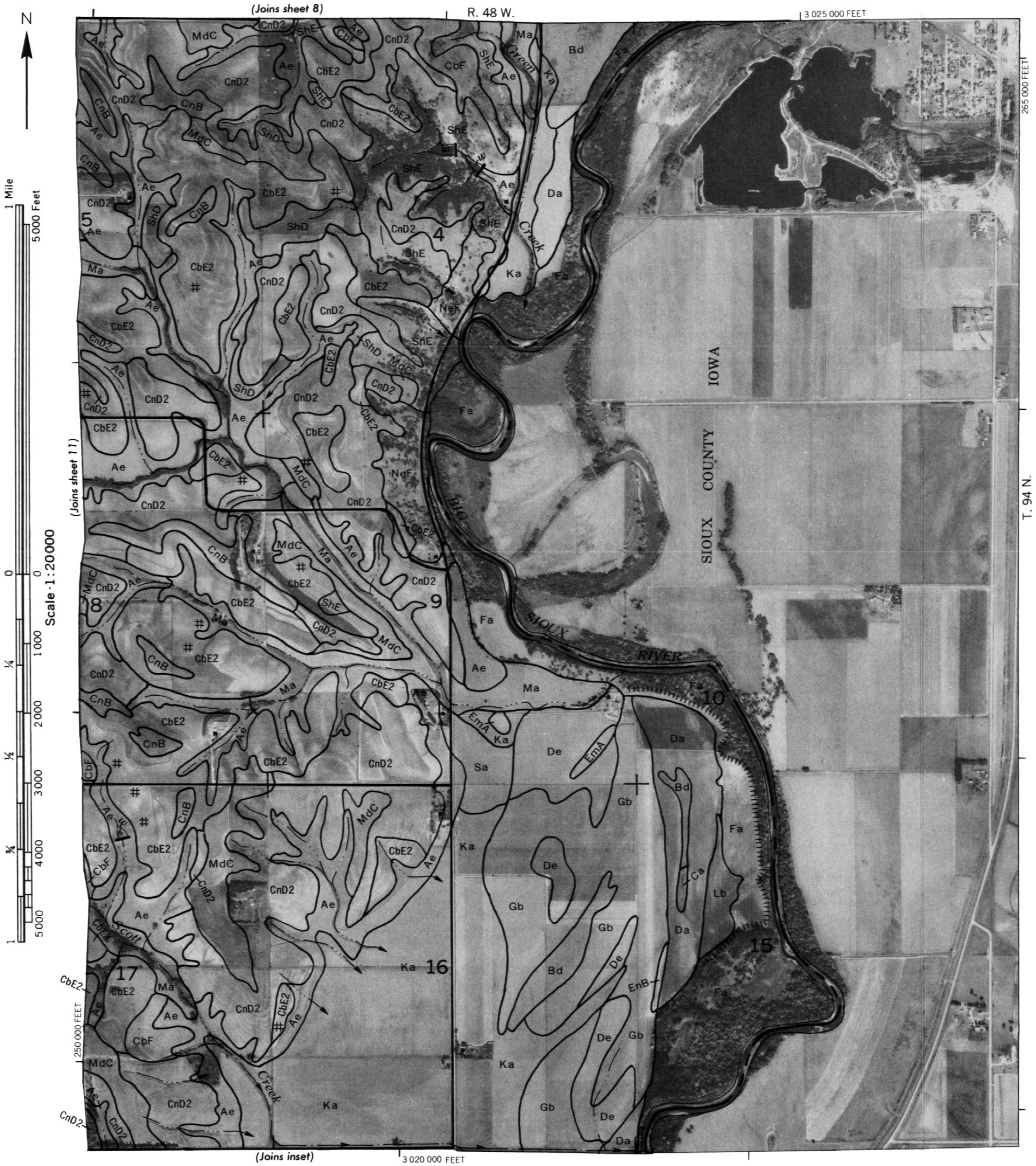


This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned

UNION COUNTY, SOUTH DAKOTA NO. 10



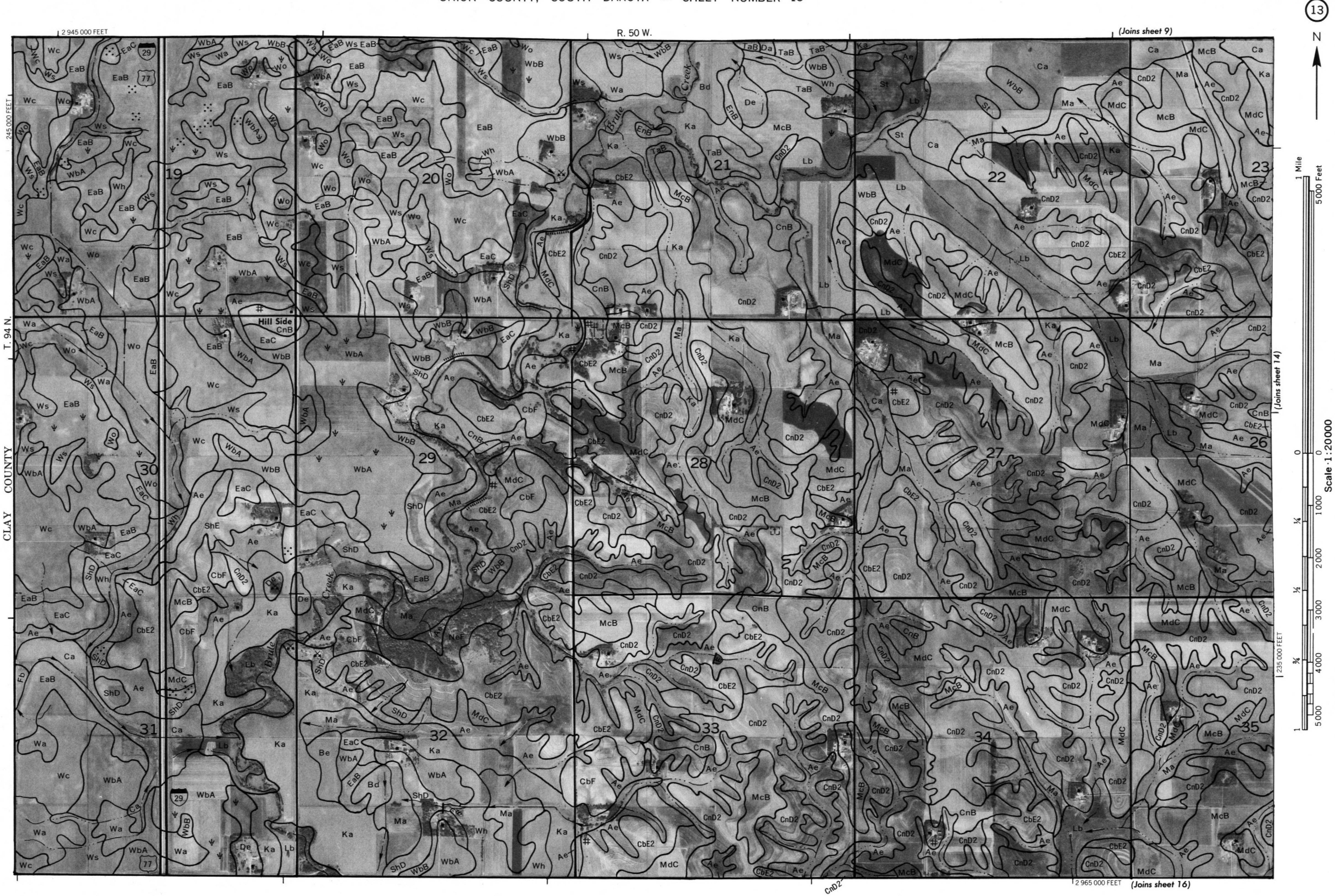
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



3000 AND 5000-FOOT GRID TICKS

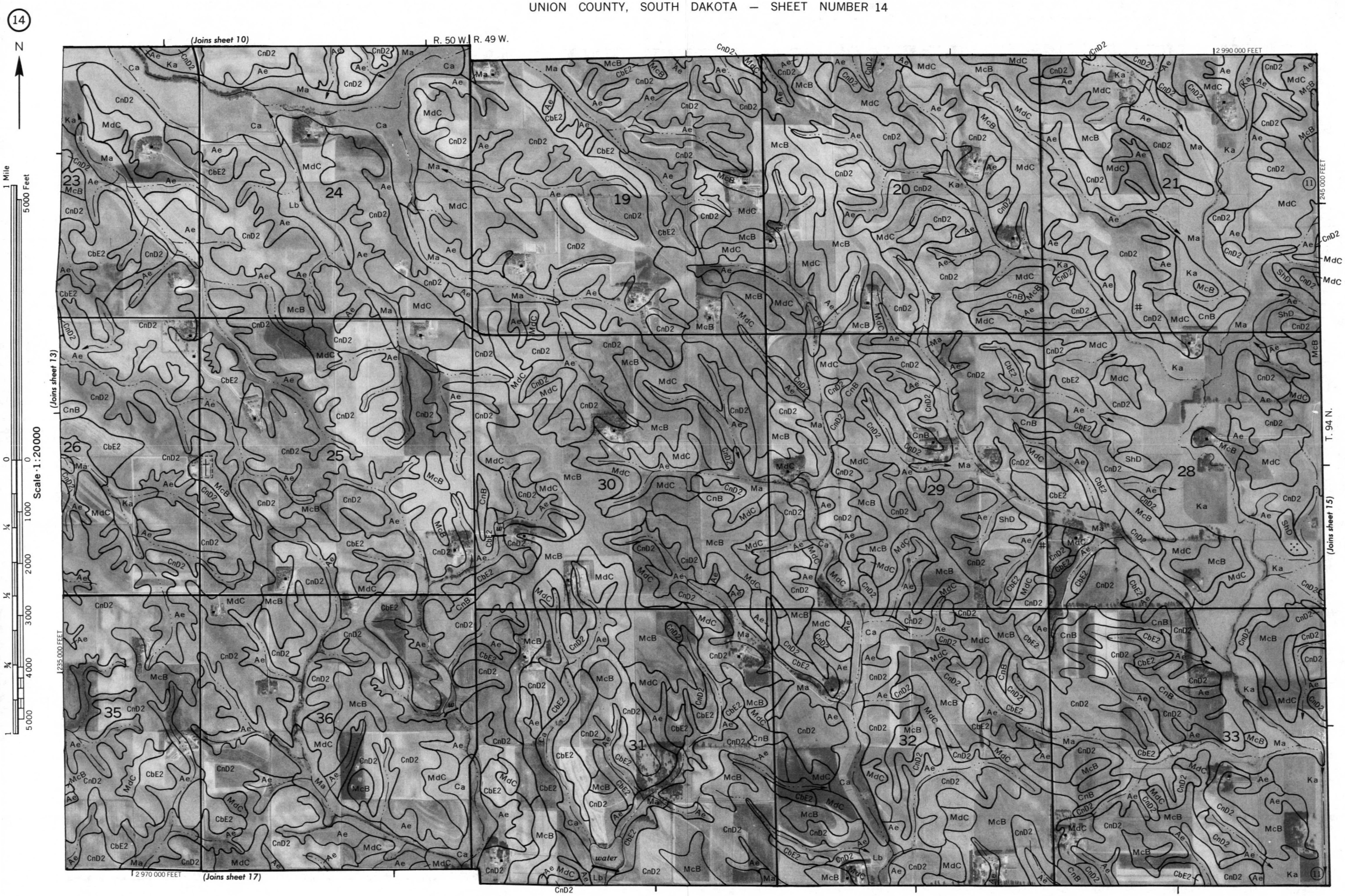
This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 12



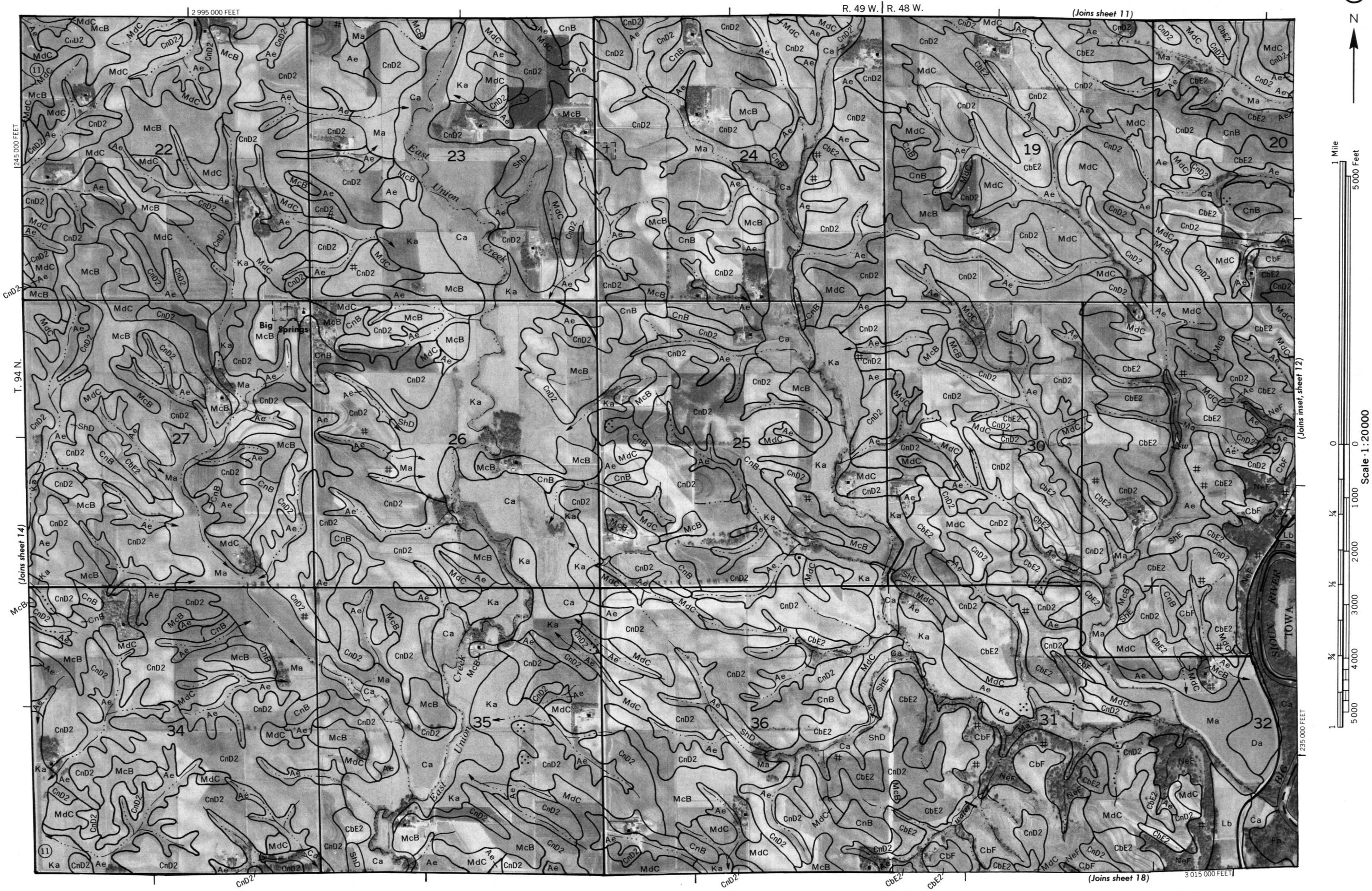
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 13

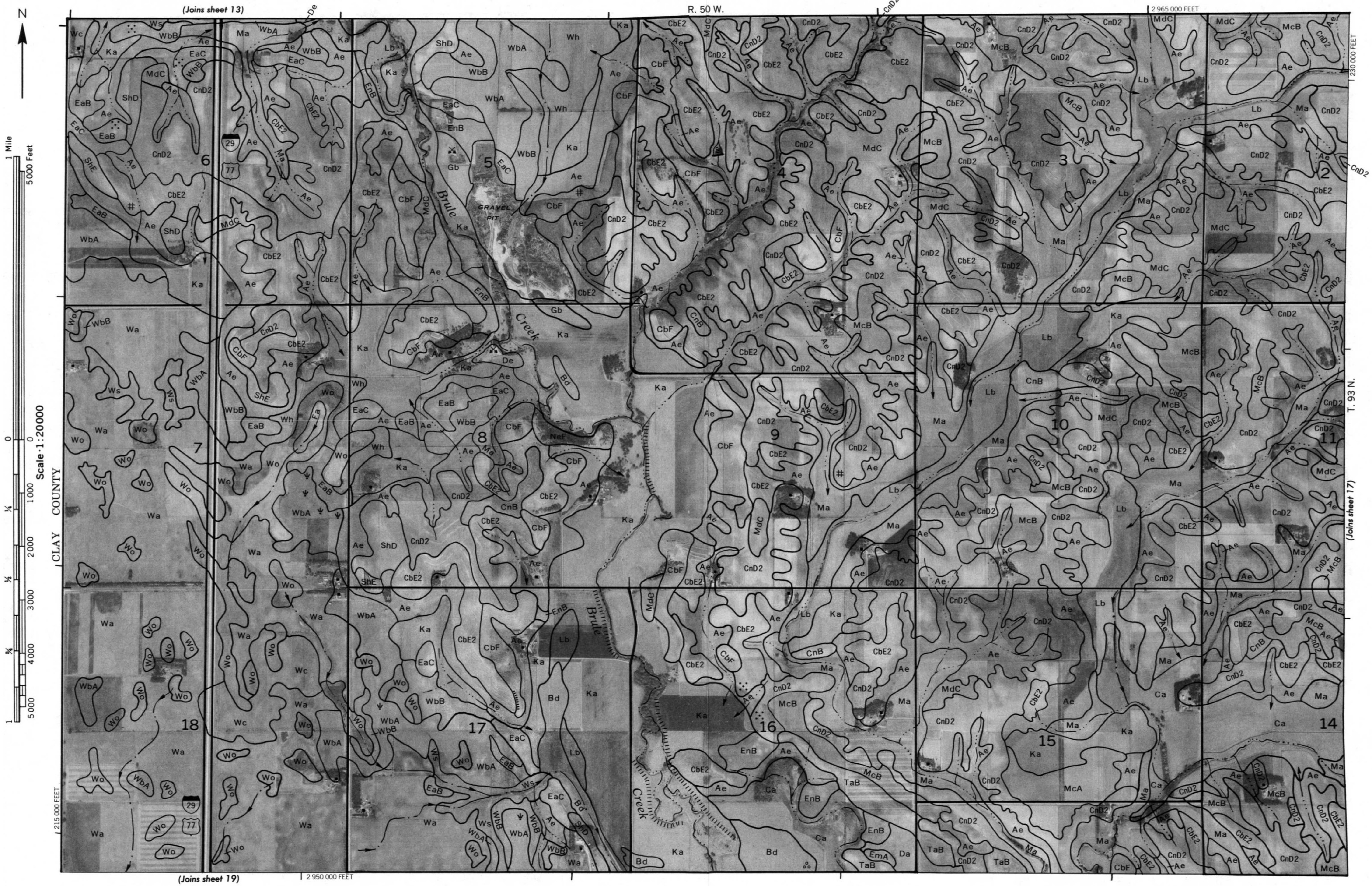


This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

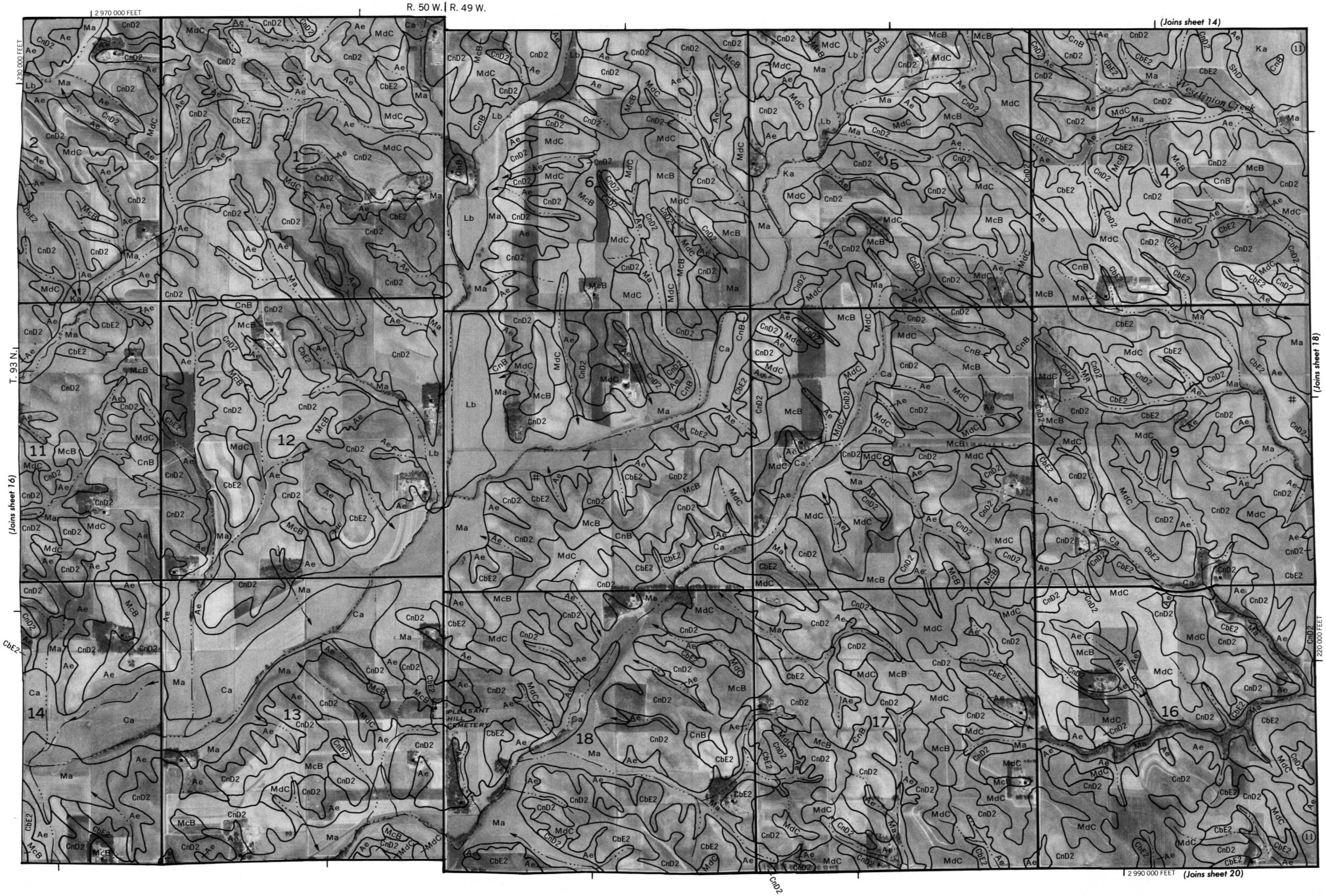
UNION COUNTY, SOUTH DAKOTA NO. 14

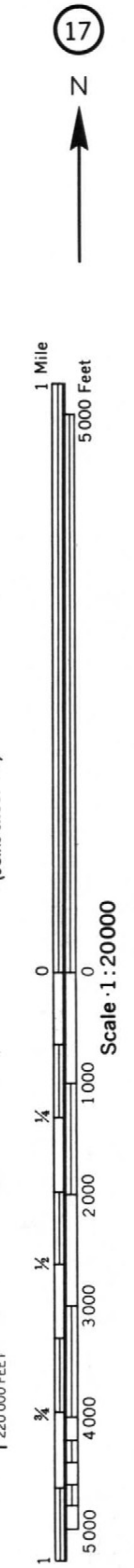


This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

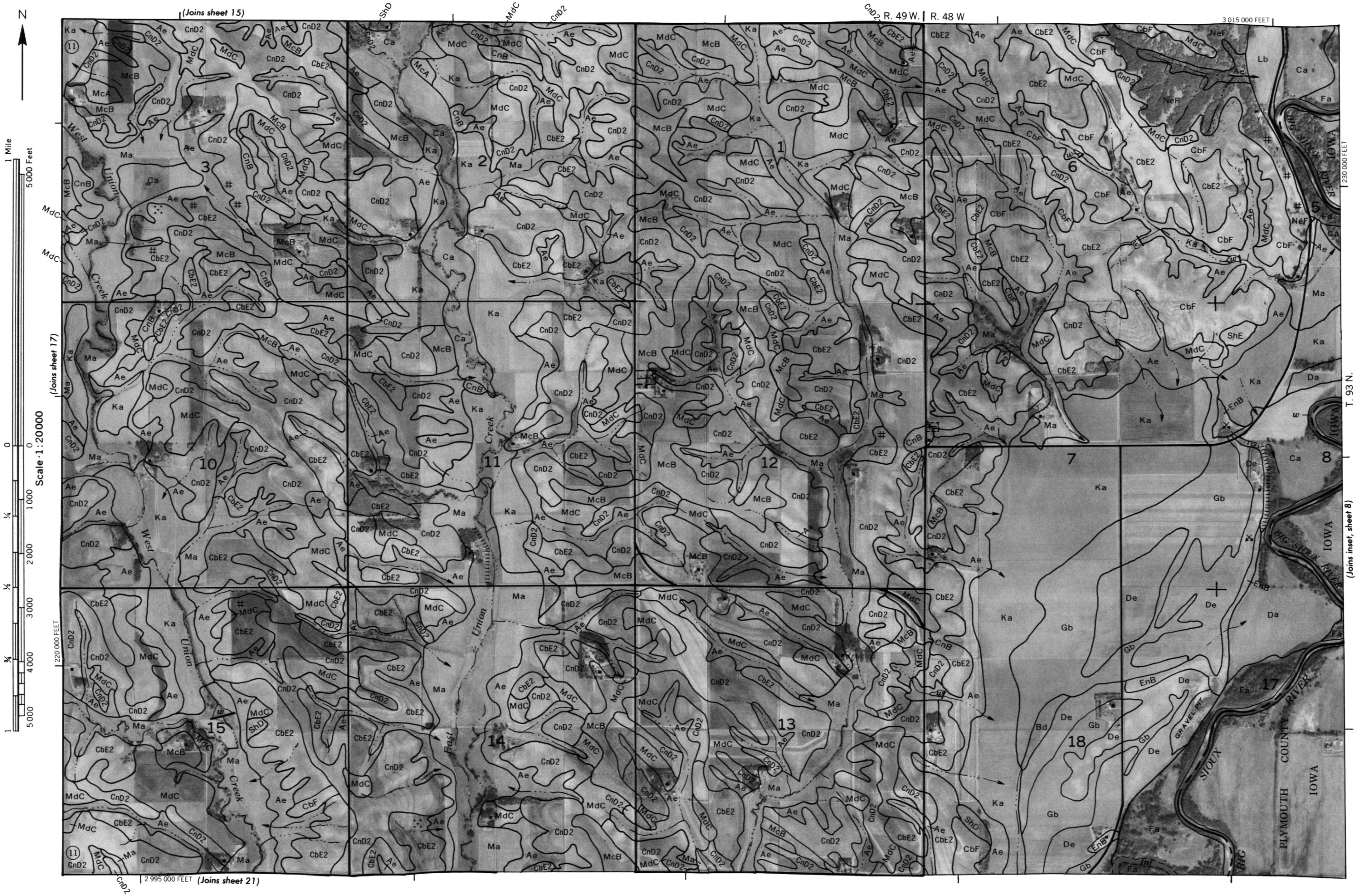




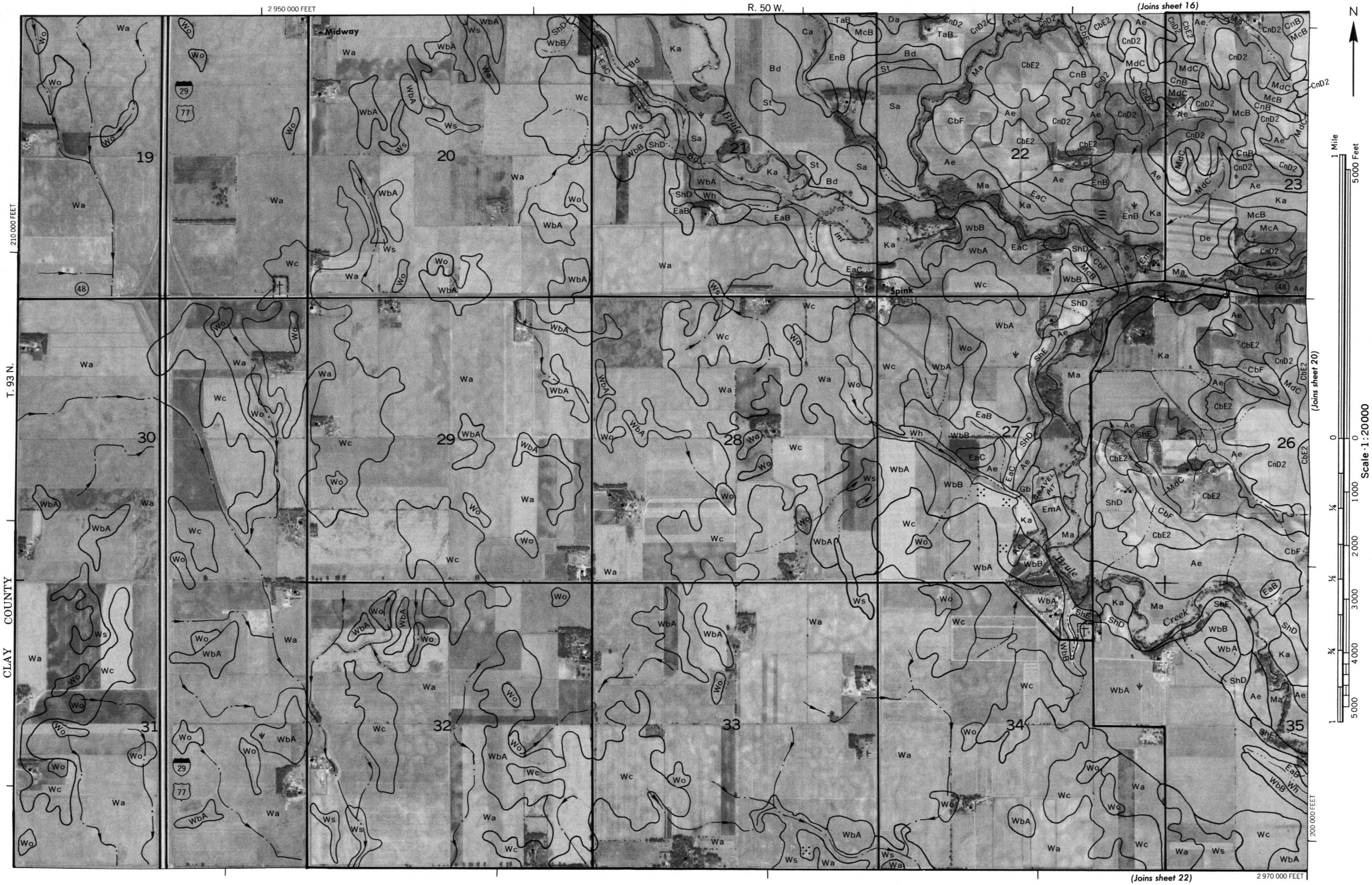
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 17

UNION COUNTY, SOUTH DAKOTA — SHEET NUMBER 18

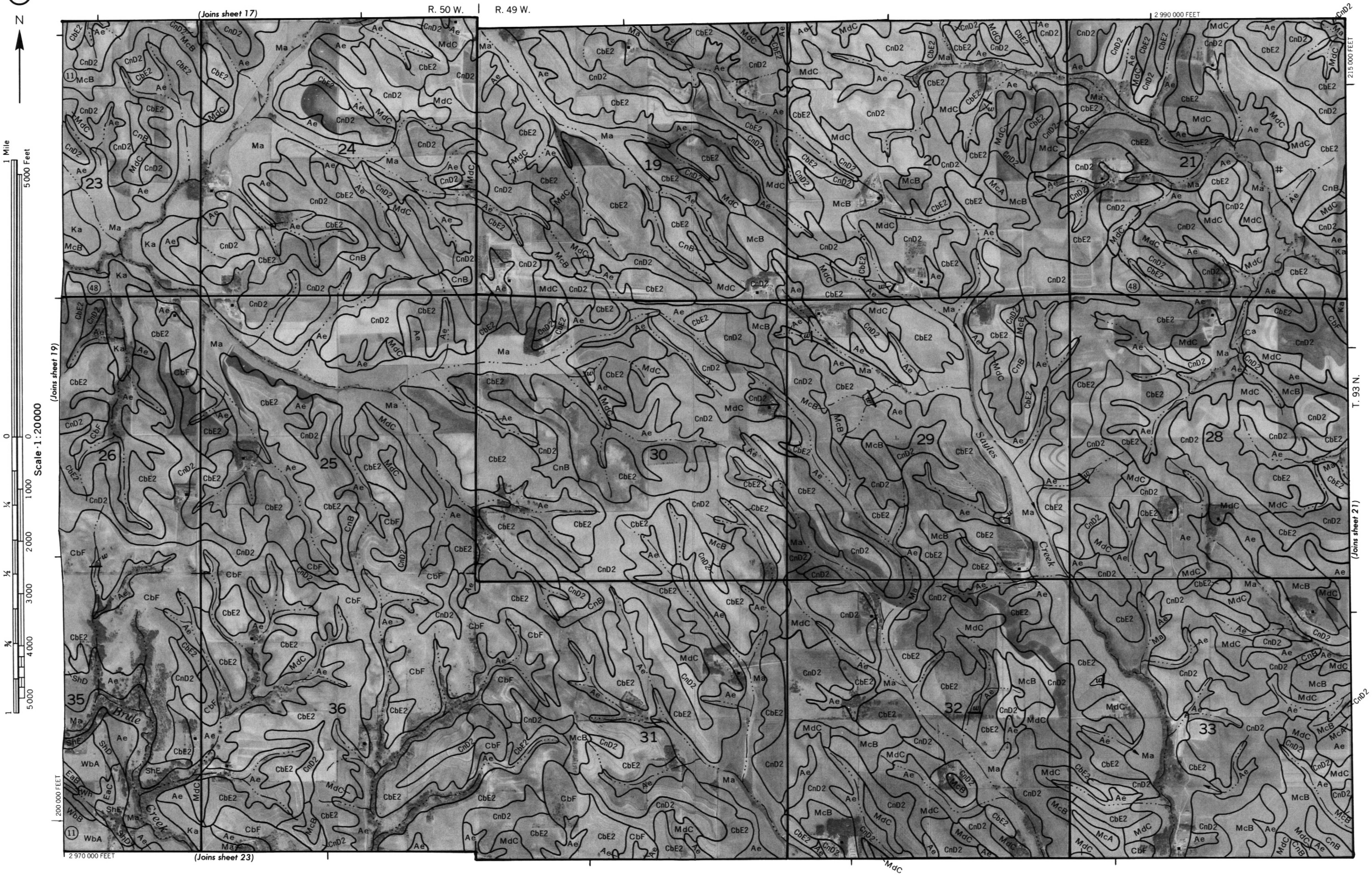


This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.



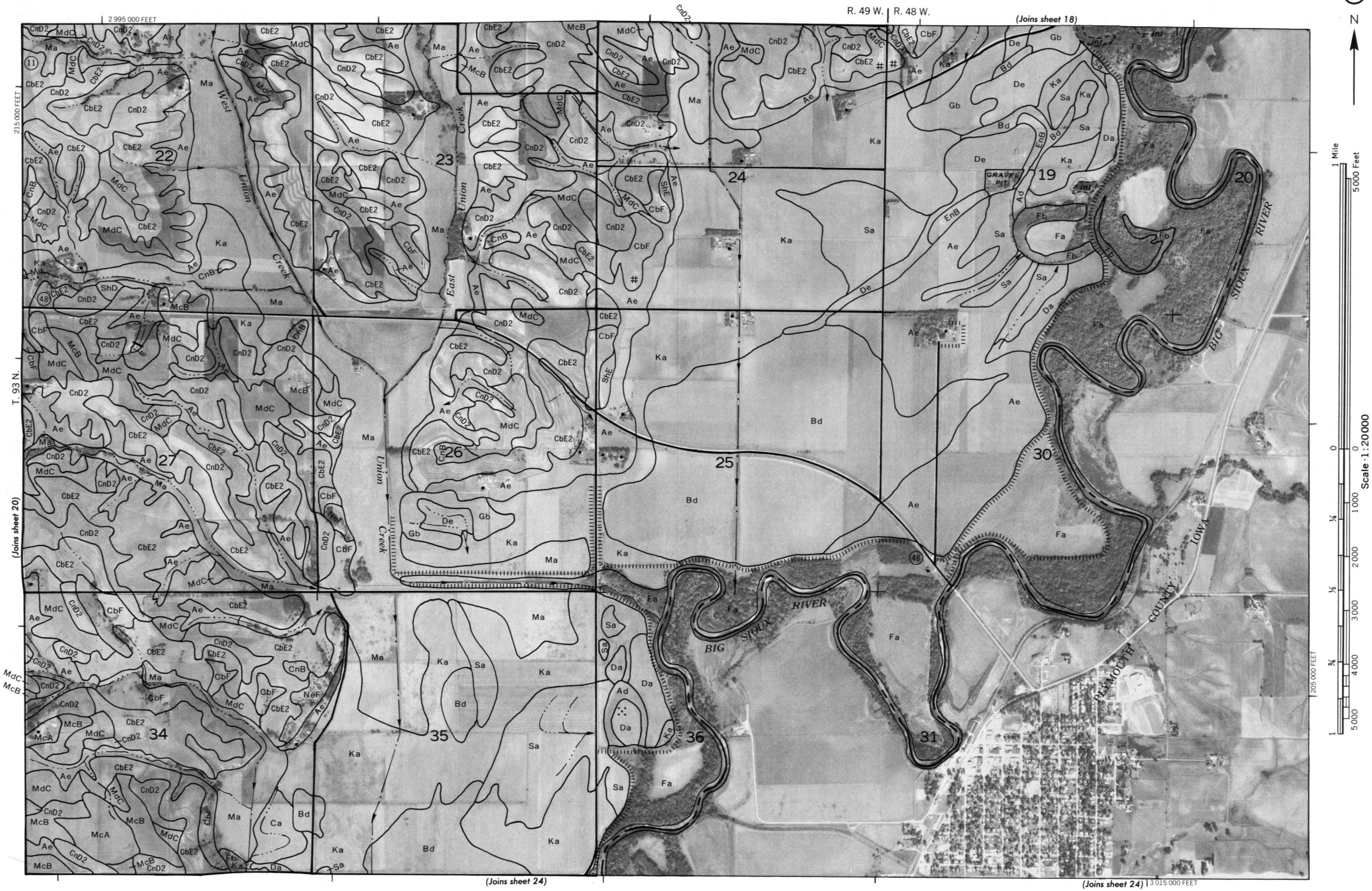
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 19



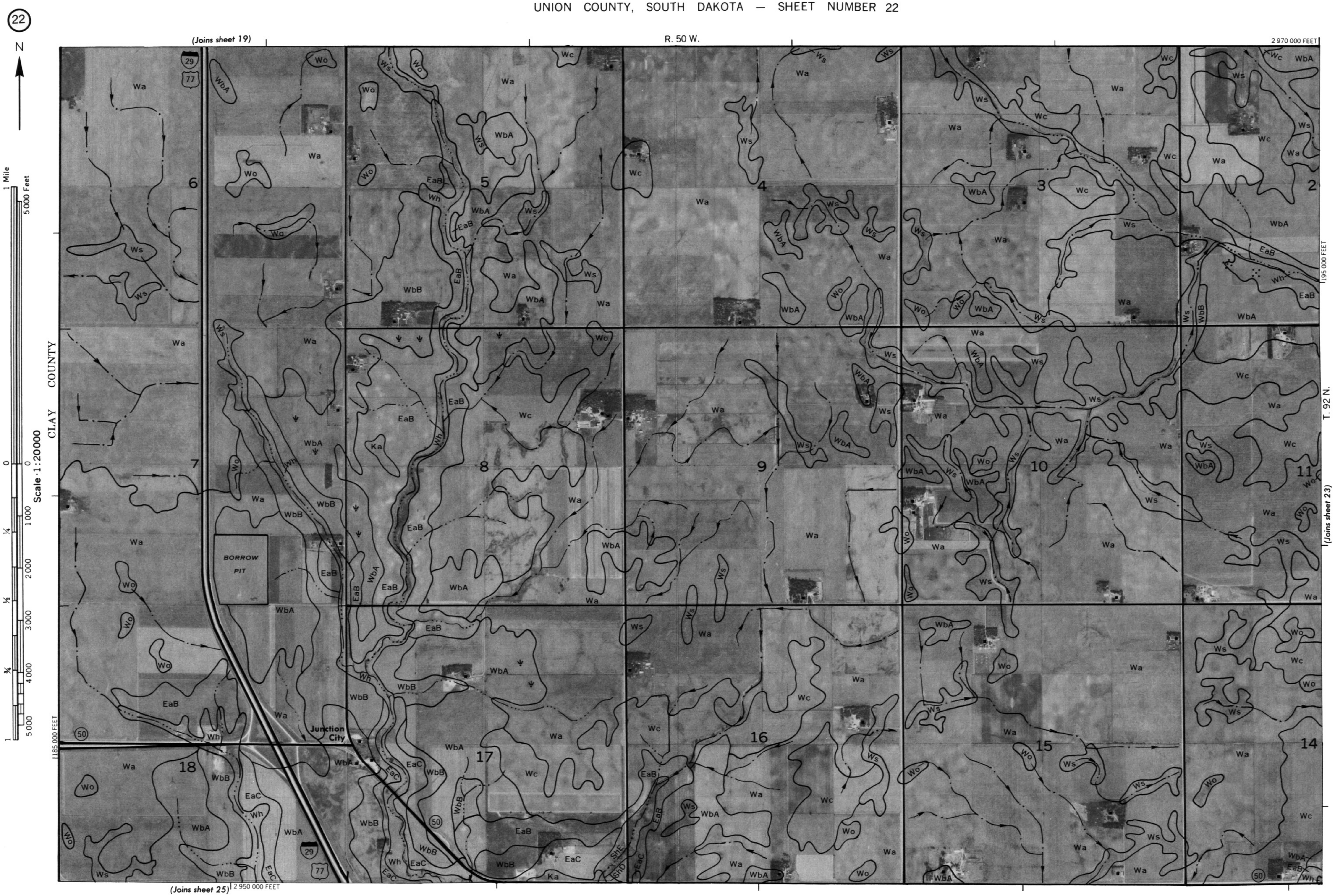
This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 20



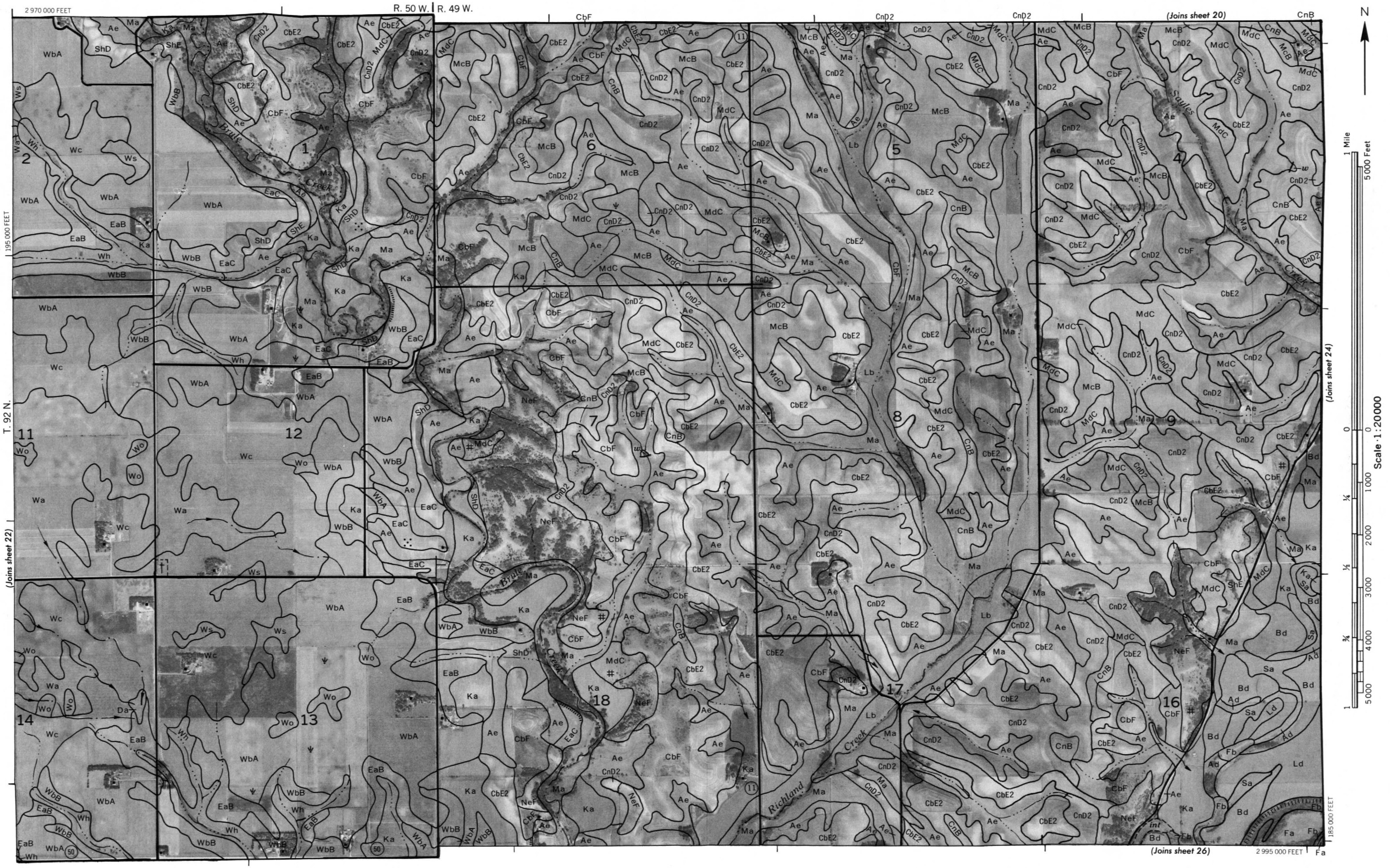
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 21



This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 22



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 23

UNION COUNTY, SOUTH DAKOTA — SHEET NUMBER 24

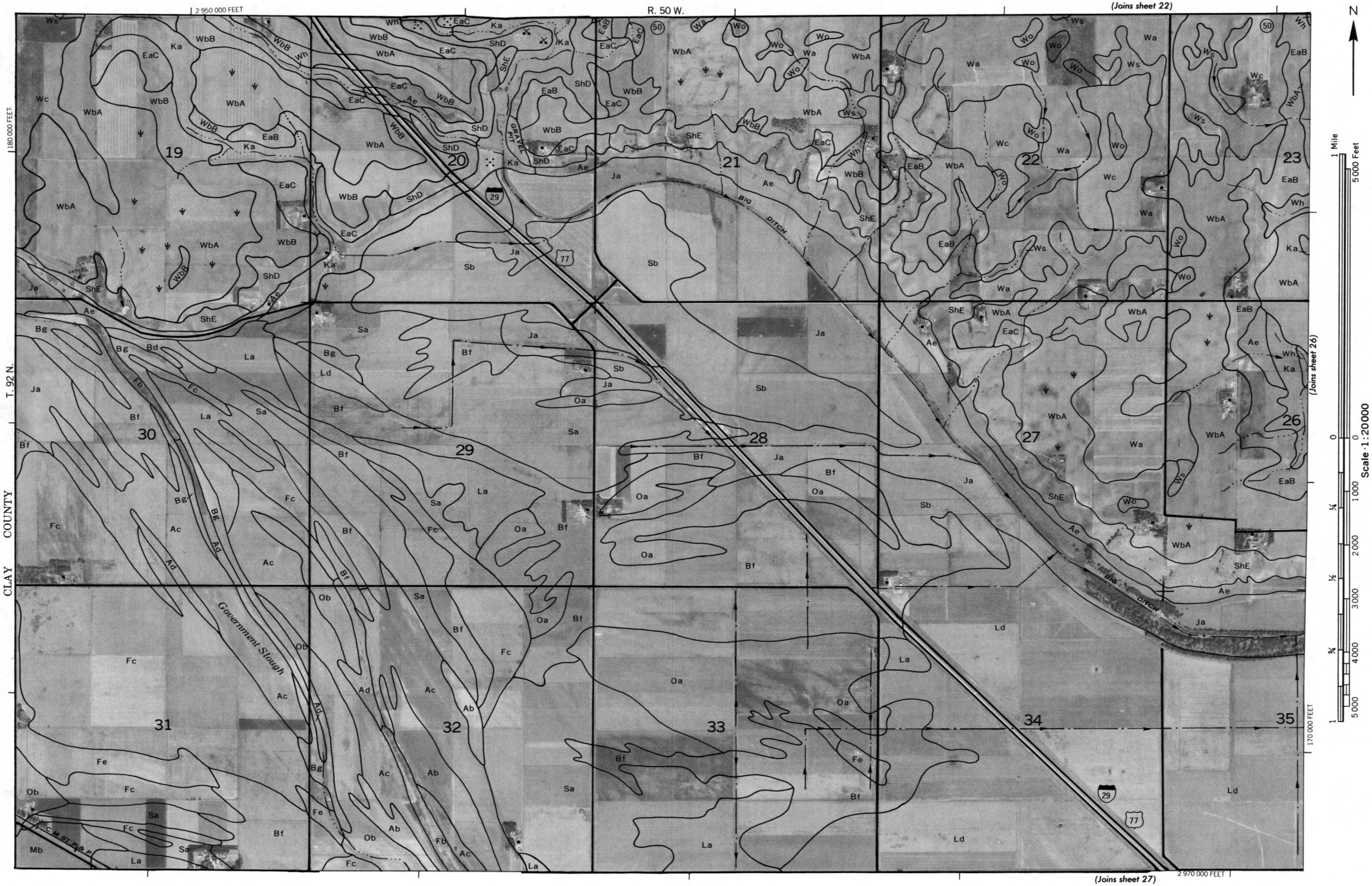
3000 AND 5000-FOOT GRID TICKS

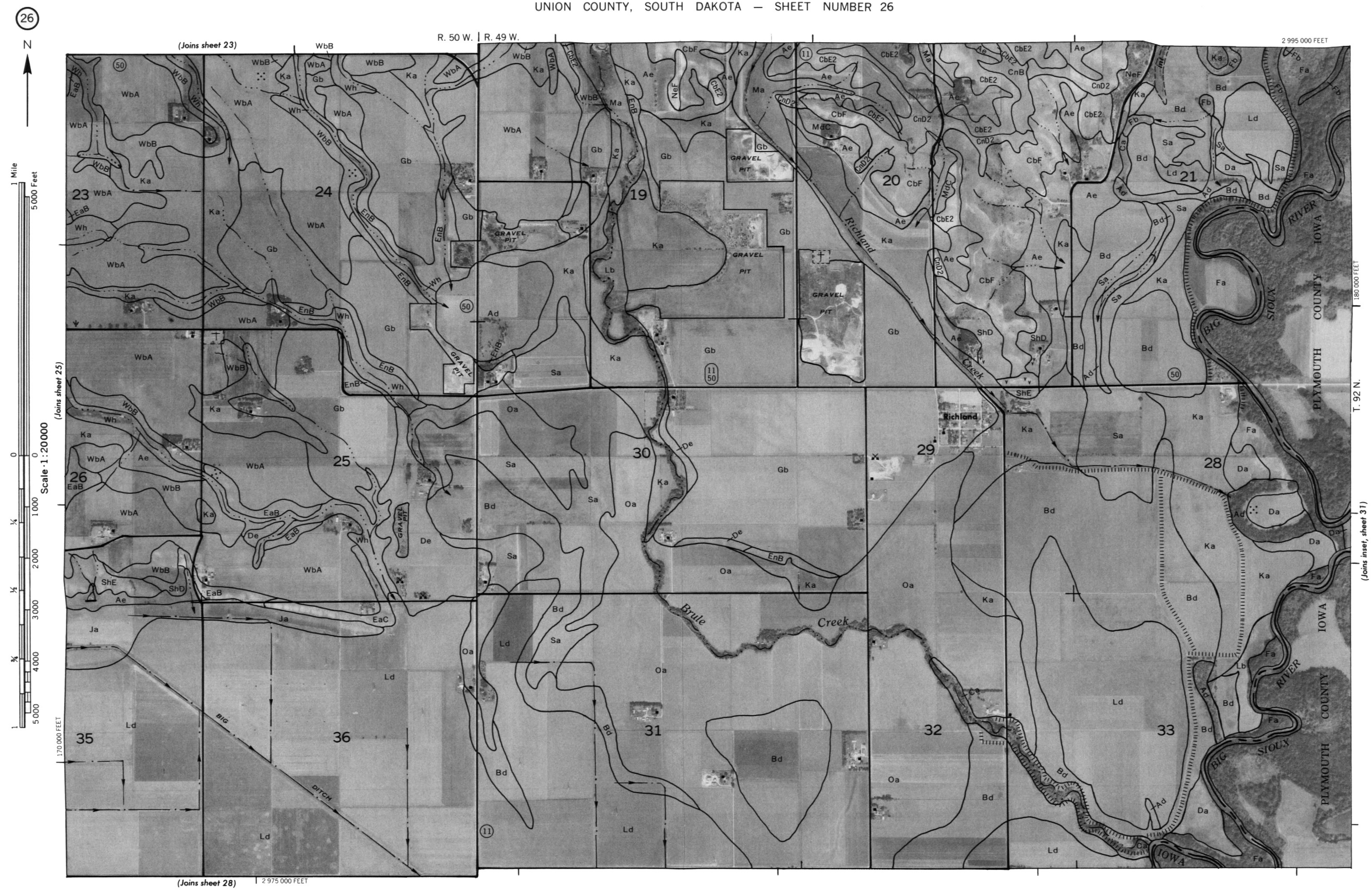
This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 24

25

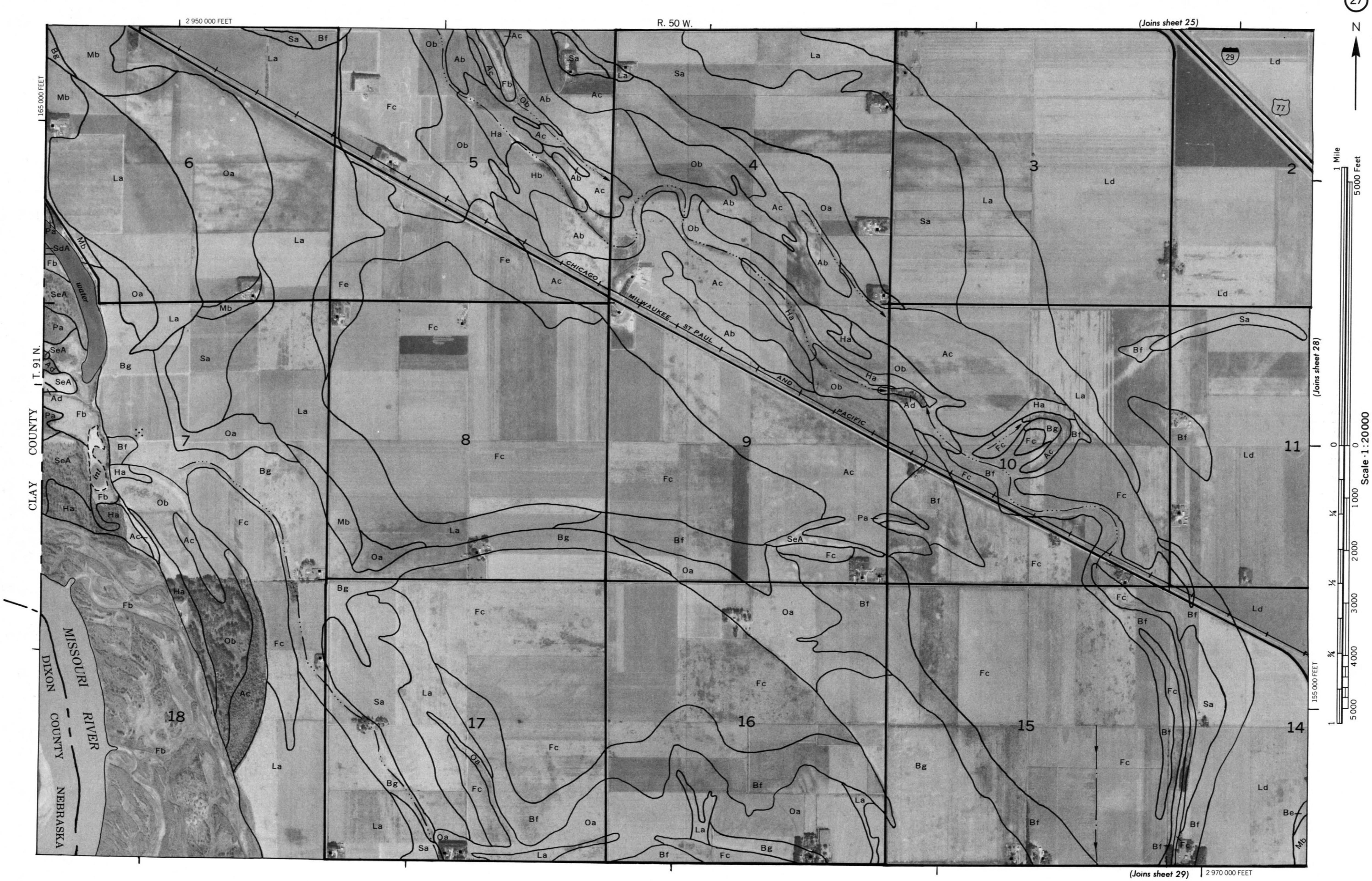
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.
UNION COUNTY, SOUTH DAKOTA NO. 25





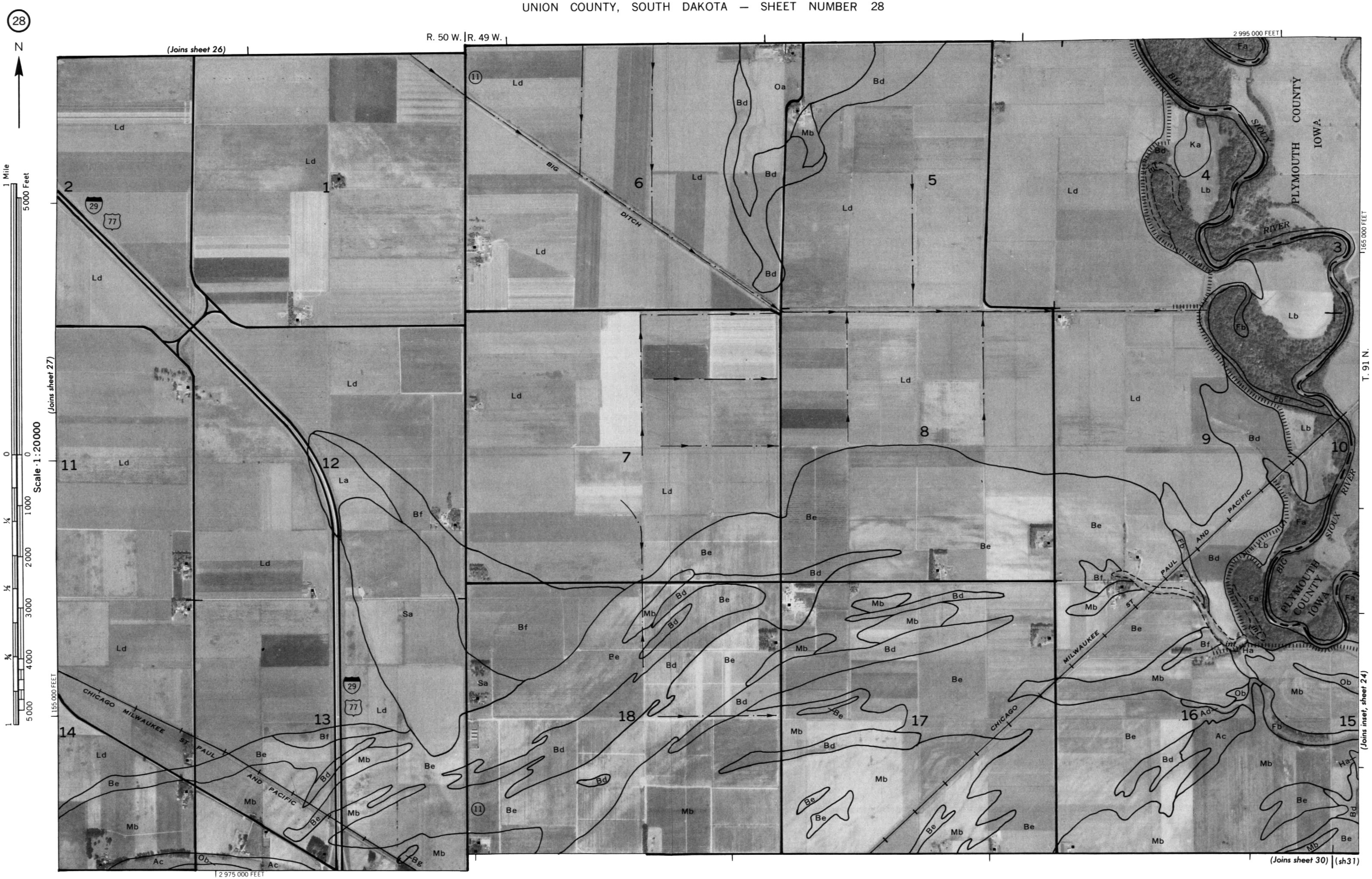
UNION COUNTY, SOUTH DAKOTA NO. 26

This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.



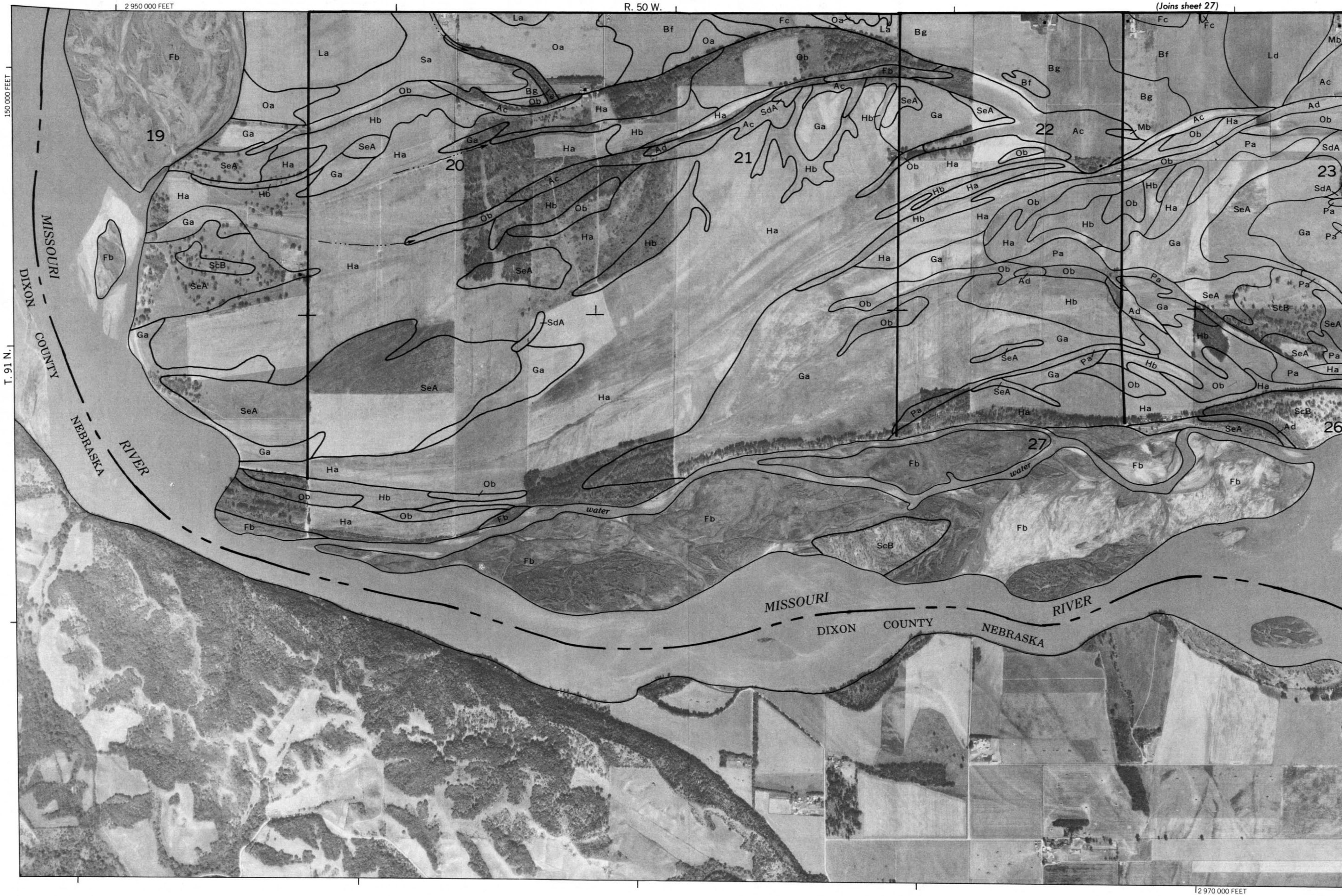
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 27



This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 28



N

Scale 1:20 000

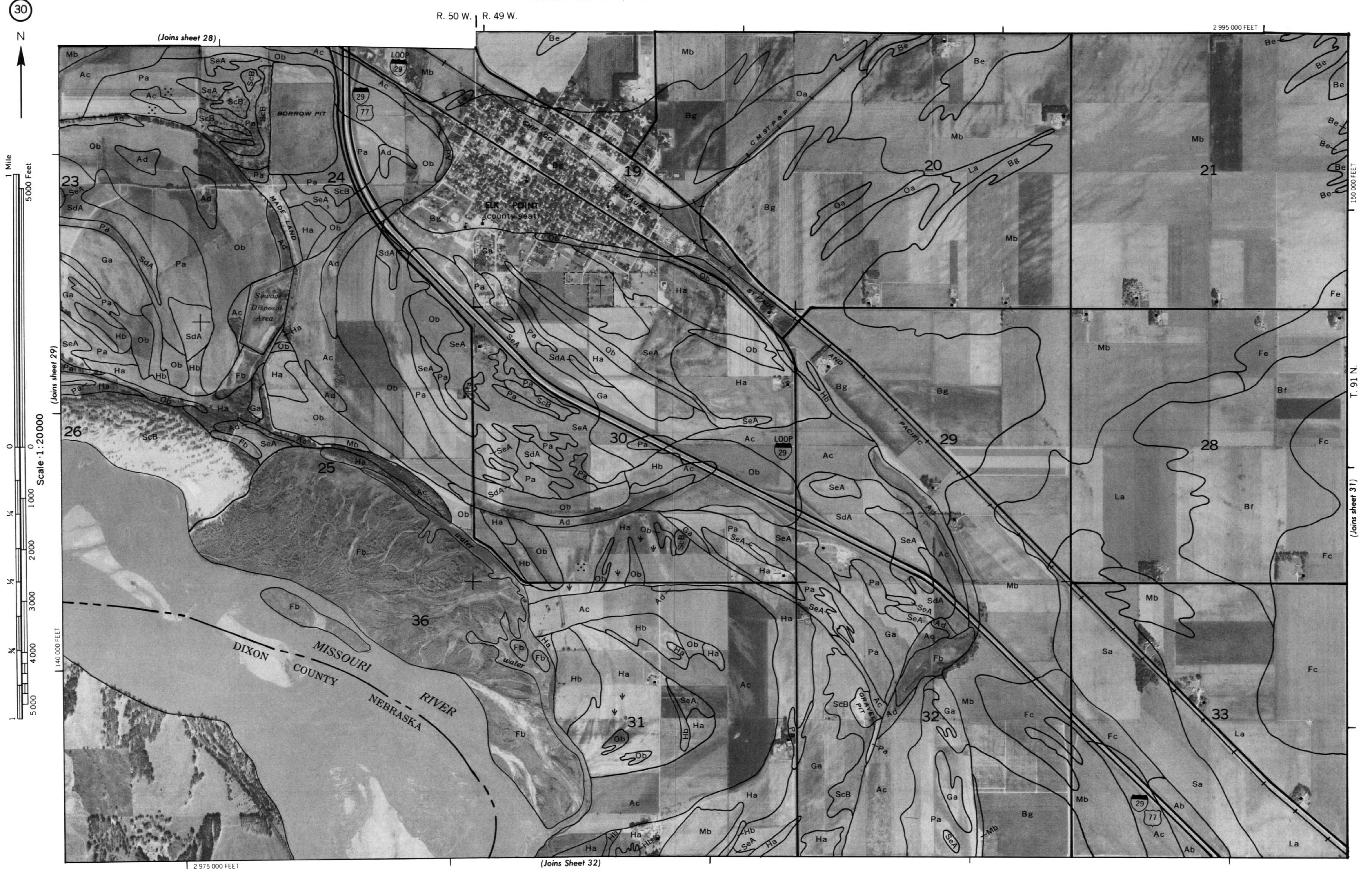
1 Mile

5 000 Feet

0 1 000 2 000 3 000 4 000 5 000

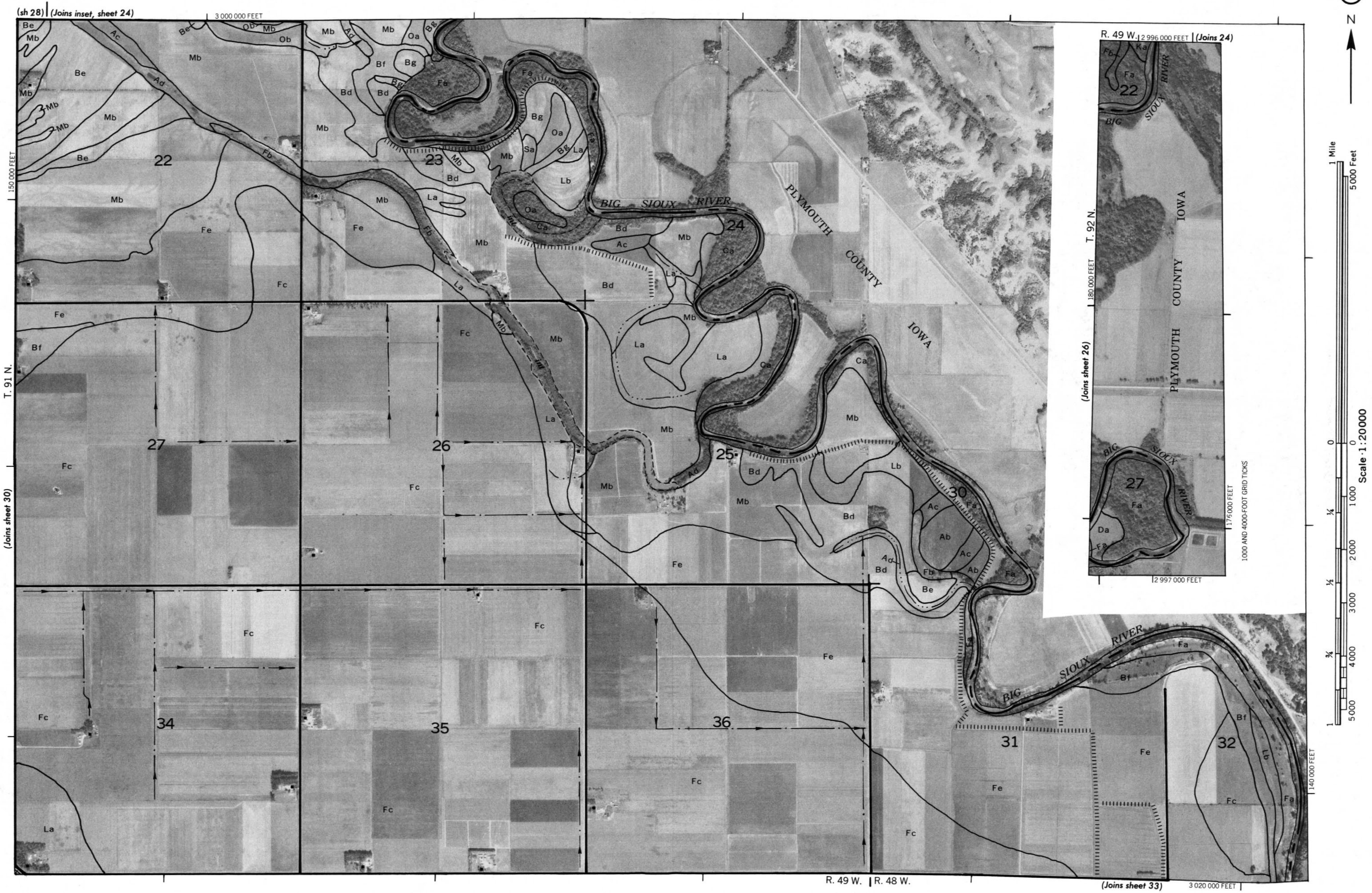
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 29



This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

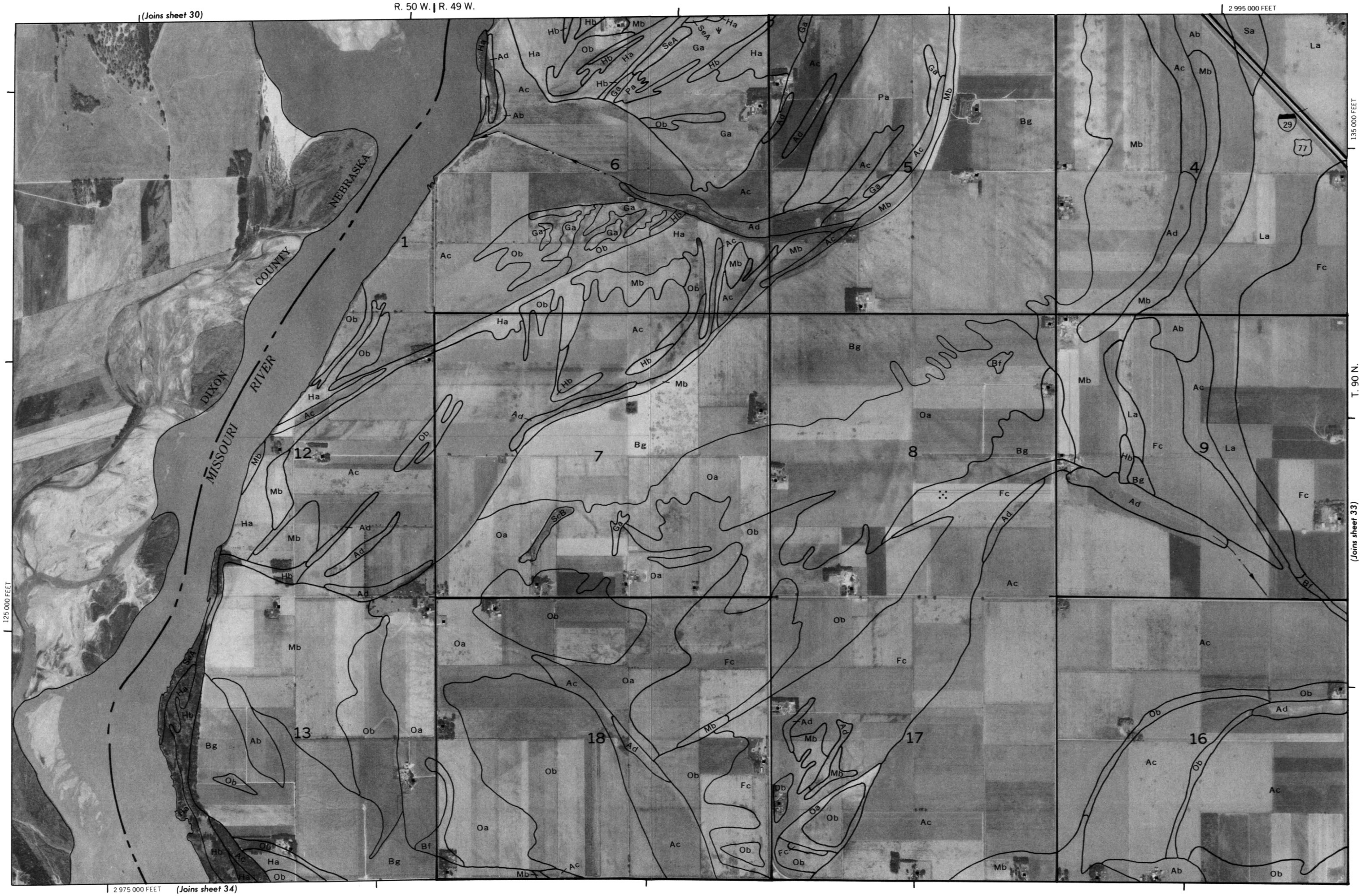
UNION COUNTY, SOUTH DAKOTA NO. 30



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA — SHEET NUMBER 32

N



1 Mile
5 000 Feet
Scale 1:20000
0 ¼ ½ ¾ 1
0 1000 2000 3000 4000 5000

This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 32

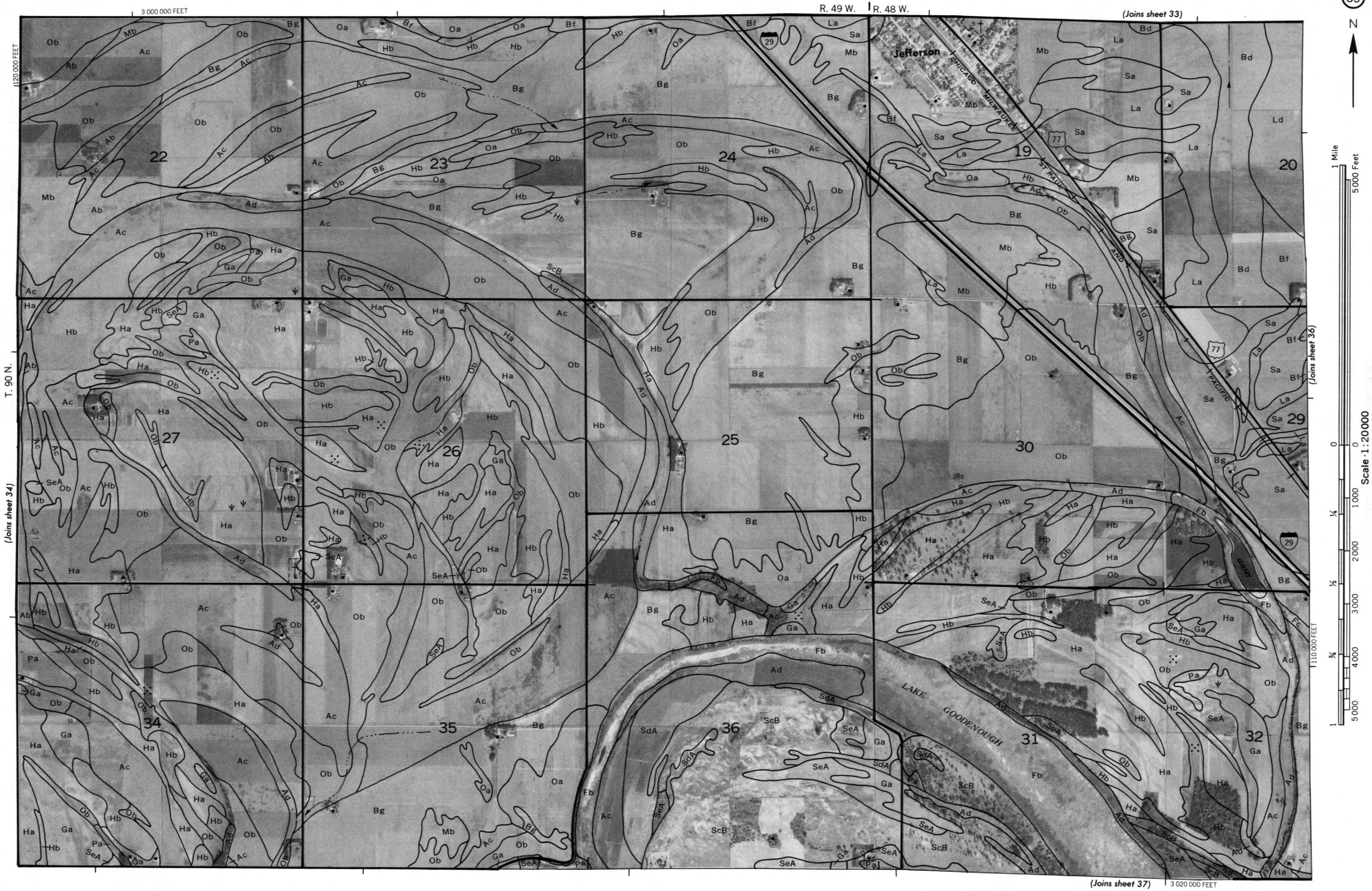
This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies.
Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 33

UNION COUNTY, SOUTH DAKOTA — SHEET NUMBER 34

This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 34



This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 35

This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 37

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA — SHEET NUMBER 38

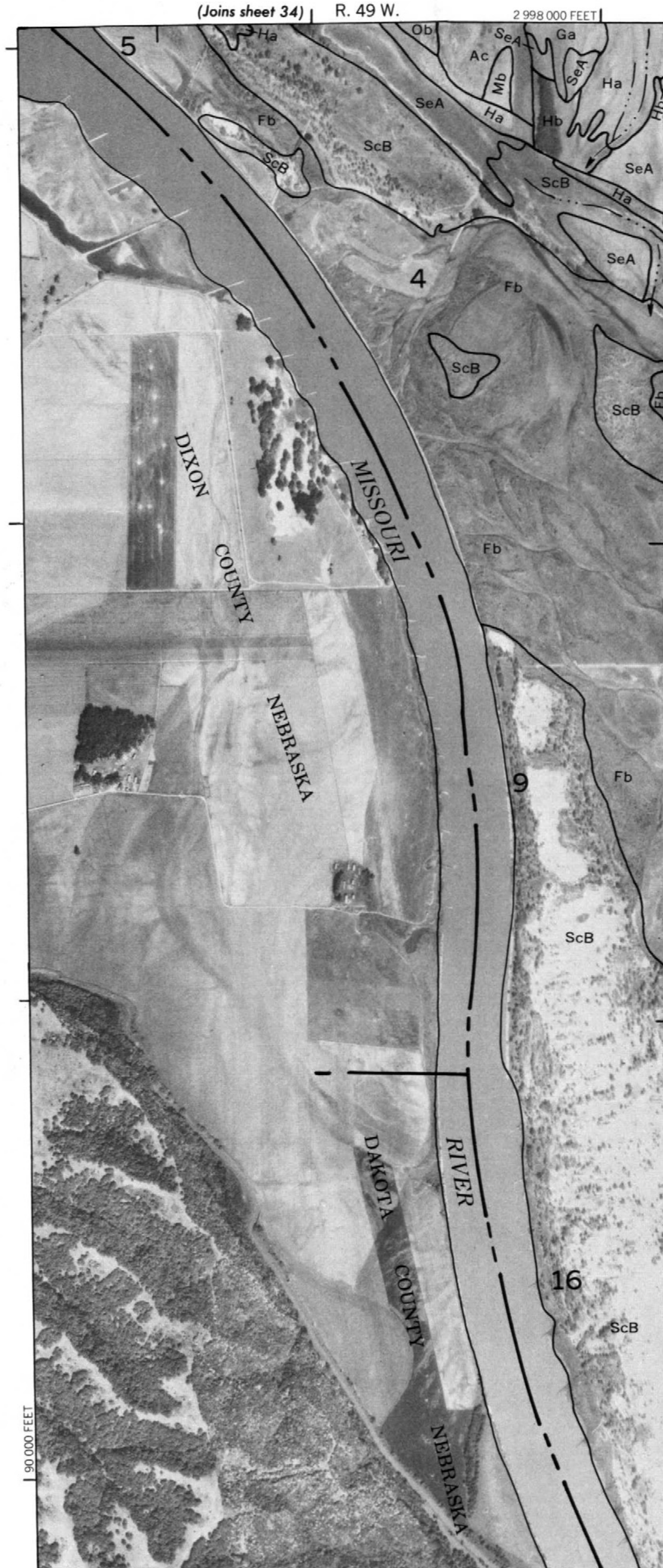
N

1 Mile
5000 Feet
Scale 1:20000

This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 38

(Joins inset) (Joins sheet 37)



N

Scale 1:20000

1 Mile — ¾ — ½ — ¼ — 0

5000 Feet — 4000 — 3000 — 2000 — 1000 — 0

3000 AND 5000-FOOT GRID TICKS

This map is compiled on 1974 aerial photography by the U. S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 39

UNION COUNTY, SOUTH DAKOTA — SHEET NUMBER 40

This map is compiled on 1974 aerial photography by the U.S. Department of Agriculture, Soil Conservation Service and cooperating agencies. Coordinate grid ticks and land division corners, if shown, are approximately positioned.

UNION COUNTY, SOUTH DAKOTA NO. 40